MACHINERY
March, 1910

METAL SPINNING—1*

By WILLIAM A. PAINTER†

THE principal object of this article is to describe in detail the various operations of spinning metal so that a tool-maker or machinist who has not access to a metal spinner, will be able to make his own tools, rig up an engine or speed lathe, and make the simple forms or models that are required in experimental work. To do this intelligently, it is necessary to follow in detail every step in metal spinning from the circular blank to annealing, pickling, dipping, burnishing, etc., and also to know how to make the simpler forms of spinning tools, what lubricants to use on the

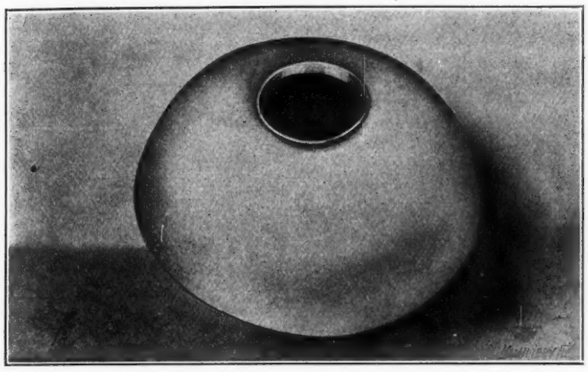


Fig. 1. Zinc Lamp Shade Spun in One Operation without Annealing

different kinds of metals, what material to make the spinning chucks of, and how far the metal can be worked before annealing.

Spinning metal into complicated and elaborate shapes, is an art fully as difficult as any craft, and the man is truly an artist that can make artistic and graceful outlines in metal, especially when only a few pieces are required and the cost will not allow of making special chucks to do the work on and with no outline chucks to govern his design, the forms being made by skill and manipulation of tools alone. Such skill is far superior to that of the Russian metal worker, who, instead of making a vase or ornament of one piece, cuts

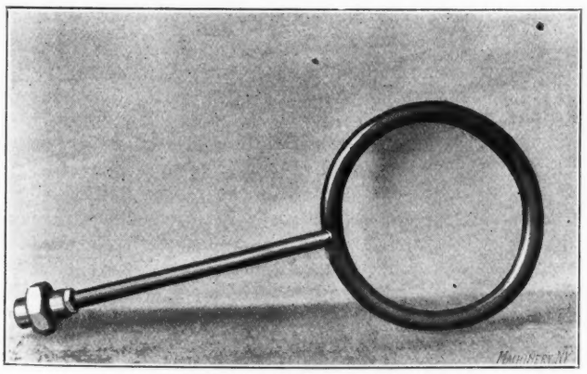


Fig. 2. Gas Burner for Heating Spinning Chuck

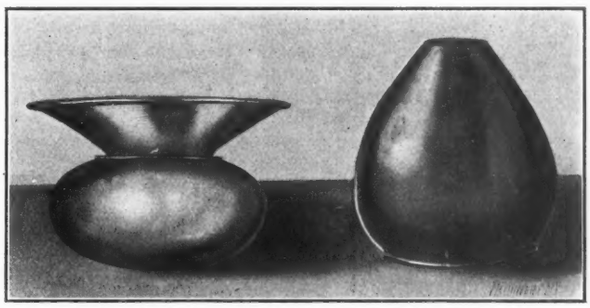
up several sections and soft solders them together, after covering them with crude "gingerbread" work to disguise his poor metal work.

The amateur can imitate the Russian work, but never the work of the skilled spinner. There are several grades of spinners, most of them never attaining the skill of the model-maker or the facility for handling the different metals. A man that has had several years of experience spinning brass or copper would not be able to spin Britannia or white metal without stretching it to a very uneven thickness. As brass or copper is harder than the other metals mentioned, they resist the tool more and require more pressure in forming, and if the operator used the same pressure on the softer metals, he would stretch or distort them, so that they would be perhaps one-quarter of the original thickness at angles and corners where the strain in spinning would be greatest, which would ruin the articles. The best test for skill in ordinary spinning, is to take a long difficult shape, after being finished, and saw it in two lengthwise, and if the variation in thickness is less than 25 per cent of the original gage, it is good practice. Some spinners can keep within 10 per cent of the gage on ordinary work, but they are scarce.

The spinning trade in this country is mostly followed by foreigners, Germans and Swedes being the best. The American that has intelligence and skill enough to be a first-class spinner, will generally look around for something easier about the time that he has the trade acquired. It is an occupation that cannot be followed up in old age, as it is too strenuous, the operator being on his feet constantly, and having to use his head as well as his muscles.

General Remarks on Metal Spinning Chucks

For common plain shapes, a patternmaker's faceplate, with a tapered center screw, is sufficient for holding the wood chuck. The hole in the wood should be the same taper as



Figs. 3 and 4. Examples of Aluminum and Copper Spinning

the screw, thus giving an even grip on the thread. If a straight hole only is used, and it is not reamed out before screwing to the plate, it will only have a bearing on one or two threads, and if the chuck is taken off and replaced on the faceplate, it will not run true. Care should also be taken to face off the end of the chuck flat, or to slightly recess it, so that it will screw up evenly against the faceplate, as a high center will cause it to rock and run out of true.

In large chucks (over five inches) it is best to have three or four wood screws, besides the center screw. The holes for these can be spaced off accurately on a circle in the iron faceplate, and drilled and countersunk. It is best to have twice as many holes as screws; that is, if four screws are used there should be eight holes, so that if the chuck has to be replaced at any time and the wood has shrunk, it can be turned one-eighth of a revolution further than the original chucking.

Where a chuck has to be used several times, it is better practice to cut a thread in the wood and screw the chuck directly to the spindle of a lathe, not using the faceplate. This thread can be chased with a regular chasing tool, where the operator has the skill, and, if not, the wood can be bored out and a special wood tap used. Such a tap has no flutes and it is bored hollow, there being a wall about 3/16 inch thick. One tooth does all the cutting, that being the end of the thread. The chips go into the hollow part of the tap. The end of the tap for about ¼ inch should have the same diameter as the hole before threading to act as guide for the cutting tooth.

* See also the article, Methods and Tools Used in Metal Spinning, published in the December, 1909, number of MACHINERY.

† Address: 1515 Franklin St., Pittsburg, Pa.

It is essential that a chuck should run very true and be balanced perfectly, as the high speed at which it runs will cause it to vibrate and run out of true, causing the finished metal to show chatter marks. The best wood for chucks is hard maple, and it should be selected for its even grain and absence of checks and cracks. It is best to paint the ends with paraffine or red lead, or to immerse the chucks in some vegetable oil after turning. Cotton seed oil is very good for this purpose, but care should be taken not to soak the chucks too long.

For a man not skilled in spinning, it is better to use metal chucks than wood, for if there are many shells of a kind, the operator is liable to bear too hard on the tool, thus compressing the chuck and making the last shells smaller than the first. Corners and angles that are not well supported might also be knocked off. I prefer cold rolled steel for chucks up to 6 inches in diameter and cast iron for the larger ones, but where good steel castings can be obtained a good chuck can be made by turning roughly to shape a wood pattern, allowing enough for shrinkage and finishing, and hollowing

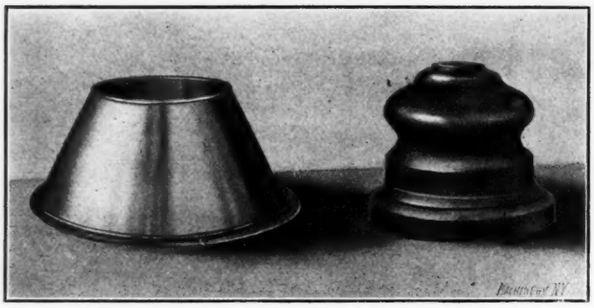


Fig. 5 .German Silver Reflector Fig. 6. Open-hearth Cold-rolled Steel Shell

out the back to lighten it. When the casting is finished all over in the lathe, it should balance much better than a cast iron one as there are not the chances of having blow holes in the iron thus throwing the chuck out of balance.

Annealing

The distance that metal can be drawn without annealing, can only be learned by experience. A flat blank rotated on the lathe, being soft, will offer little resistance and it can be gradually drawn down by a tool held under the chuck and against the blank. This tool is pushed from the center outward and forward at the same time, and every time it passes over the blank or disk the metal becomes harder by friction and the change of formation and the resistance at the point of the tool greater. This can be felt as the tool is under the operator's arm. When the spring of the metal is such that the tool does not gain any but only hardens the metals, the shell should be taken off and annealed. If the metal has

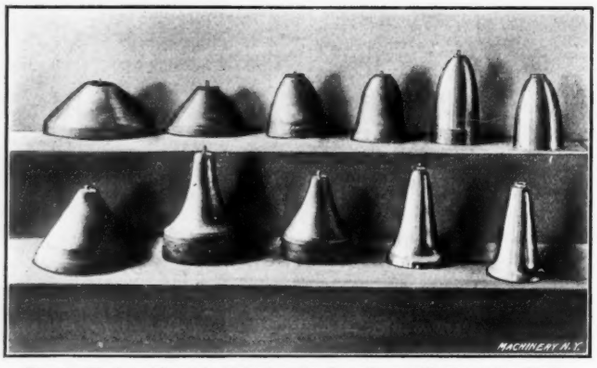


Fig. 7. Various Steps in Spinning the Two Brass Shells at the Right

been under a severe strain, it should be hammered on the horn of an anvil or any metal piece that will support the inside. The hammer should be a wood or rawhide mallet, but never metal, the object being to put dents or flutes in the metal to relieve the strain when heating to anneal; if this is not done the shell will crack.

After annealing the shell it should be pickled to clean the oxide or scale from the surface; otherwise the metal will be pitted. Where the scale is crowded into the metal and when it will not finish smooth after spinning to shape, the metal can be finished by skimming or shaving the outer surface which cuts out all tool marks; it can then be finished with medium emery cloth or the shell can be bright dipped, and be run over with a burnishing tool before buffing. Burnishing can be done on the spinning chuck, but the speed should be

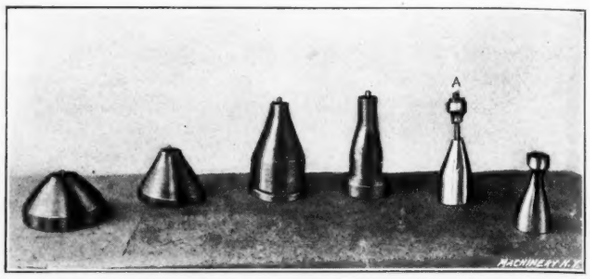


Fig. 8. Another Brass Spinning Operation; the Chuck used is shown at A

higher than for spinning; this requires some skill for a good job, and it can be done only on metal chucks.

Annealing is best accomplished in a wood or gas oven, where a forge fire is used. The metal should never touch the coke or other fuel but it should be held in the flame above the fire. Where only part annealing is required, the shell can be immersed in water, the part to be annealed being exposed above the water, and a blowpipe used on it. The remainder of the shell will then be hard. This way of annealing is sometimes necessary on special shapes.

Brass should be heated to a cherry red, and held at that point for a few minutes, in a muffle furnace. If an open furnace is used, just bring the metal to a cherry red and then dip it in water; this method anneals better than waiting for it to cool, the action being just the opposite to that of steel. Brass such as the common yellow brass is not suitable for spinning there being but 55 per cent copper and 45 per cent

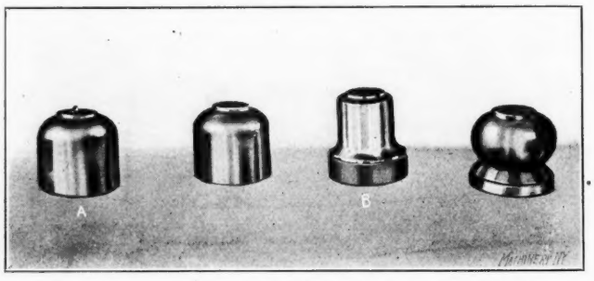


Fig. 9. An Example of "Air Spinning" and the Chucks used

zinc. There are two grades of brass suitable for spinning. These are known as "spinning and drawing," having 60 per cent copper and 40 per cent zinc, and "extra spinning and drawing" having 67 per cent copper and 33 per cent zinc. There is also a better grade known as "low brass" having from 75 to 80 per cent copper; it has the color of bronze and is only used on very deep and difficult spinning.

The scale, after annealing, should be pickled off in an acid bath (described further on in this article), and the part thoroughly washed in running water. Brass, German silver and the harder metals should be hammered before annealing; it is not necessary to hammer zinc, copper, aluminum, etc.

A pyrometer in an annealing furnace would be an advantage where quantities of the softer metals such as zinc, aluminum, etc., are being heated. Copper is annealed the same as brass and is also pickled. Zinc is coated with oil before being put in the oven, and when the oil turns brown, which occurs when the temperature is about 350 degrees, the metal is ready to take out; it should then be plunged in water to shed the scale but not pickled. The melting point of zinc is 780 degrees F. Aluminum can be annealed the same as zinc, as the melting point is 1,140 degrees F.

Steel should be annealed by heating to a cherry red and then allowing it to cool slowly; it should be scaled in a special pickle, thoroughly washed, and then put back in the fire long enough to evaporate every particle of acid that may have remained from the pickling operation. Any acid remaining

on the steel will neutralize any lubricant that is applied when spinning. Annealing should be avoided wherever possible. Open hearth steel only should be used. It should be free from scale and preferably cold rolled. Bessemer steel is not suitable, except for very shallow spinnings. Tin plate made from open hearth steel can be spun about one-half as deep as its diameter where the shape is not too irregular. German silver is difficult to spin, especially when it is over 15 per cent nickel; it has to be hammered before annealing, the same as brass, to avoid cracks.

Lubricants

Common yellow soap cut up in strips about ½ inch or ¾ inch square is a good lubricant for spinning most metals. It should be applied evenly to the disk or blank while it is revolving, by holding the soap in the hand and drawing it across the surface. Beeswax is the best for spinning steel, but it is expensive. Lard oil mixed with white-lead is a fair substitute. Either mutton or beef tallow applied with a cloth swab is very good on most all metals; also vaseline and graphite mixed to a paste and applied the same as tallow.

Fig. 10. Miscellaneous Collection of Spinning Chucks

Examples of Spinning with Various Metals

The different metals are malleable, ductile and tenacious in the following order: white metal or Britannia, aluminum, zinc, copper, low brass, high brass, German silver, steel, tin plate. White metal does not harden in spinning, but it requires special skill in handling, or the metal will be of very uneven gage. The best metal for an amateur to start on is copper, as it is both tenacious and ductile, and will stand much abuse in the fire and on the lathe. One of the peculiar properties of zinc is that it has a grain or texture, and when spinning, the two sides that went through the rolls lengthwise will be longer than the sides that have the cross grain, requiring the shell to be trimmed off quite a distance to even the edge.

To show the possibilities of working the different metals, and their relative spinning values, a number of articles made from different materials are illustrated herewith.

A zinc lamp shade is shown in Fig. 1 that is 14¼ inches in diameter and 4¾ inches deep. This shade was spun in one operation, without annealing, from a flat circular blank. All zinc should be warmed before spinning, either over a gas burner at the lathe or in hot soap water, and the chuck also should be heated, as otherwise the blank will soon chill, if spun on a cold metal chuck, as the chuck absorbs the heat long before the operation is finished. Of course this does not apply to wooden chucks. The chuck may be heated by using the burner shown in Fig. 2, which is located around the spindle of the lathe. The size of the burner should, of course, be in proportion to that of the chuck used. The burner illustrated is 8 inches in diameter. It has several small holes drilled for the gas on the side facing the chuck. The heat of the chuck is regulated by varying the supply of gas to the burner. The blank is heated before it is put on the chuck and the friction of the spinning tool helps to keep it warm until it comes in contact with the chuck. The metal retains its heat until the job is finished, and this sometimes saves an annealing operation.

In Fig. 3 is shown an example of aluminum spinning. The article illustrated is a cuspidor having a top 7¾ inches in diameter, a neck with a 4-inch flare, a diameter at the top of 9½ inches, and a height of 6½ inches. This shell was spun without annealing, which shows the extreme ductility of aluminum. The copper shell shown in Fig. 4, has a maximum diameter of 7 inches, and a depth of 8 inches; it was spun with four annealings. A German silver reflector, which is 10 inches in diameter at the largest end and 5 inches deep, is shown in Fig. 5. The spinning of such a reflector, when made from this material, is quite difficult. An open hearth cold-rolled steel shell with a maximum diameter of 3 inches and a depth of 4 inches is shown in Fig. 6. This shell was spun without annealing which shows that the grade of steel used is well adapted for this work.

In Fig. 7 two finished brass shells are shown to the right, and also the number of operations required to change the form of the metal. The upper shell is 6 inches long and 3½ inches in diameter at the large end, while the lower one is 7¼ inches long by 3¾ inches in diameter. It was necessary to anneal these shells between each operation, the upper shell being annealed four times and the lower one three times. These pieces were made in quantities sufficient to warrant the making of chucks for each operation, which enabled them to be spun with less skill than would be required if a finishing chuck only were made. When a single finishing chuck is used, the various operations in spinning a shell of this kind would be left to the judgment of the spinner, who would decide the limit of the stretch of metal between the operations before annealing.

A brass shell that is made in five operations and with four annealings is shown in Fig. 8. The finishing chuck used is a split or key chuck on which it is necessary to cut out the end of the shell in order to withdraw the key after the shell is spun. This shell, which is shown finished to the right, is 5½ inches long. It is spun smooth on a machine steel chuck, and is not skimmed, but gone over with a planishing tool at the last operation. The two pieces shown in Fig. 7 were also finished in this way.

Fig. 9 shows a brass shell, which is a good example of "air spinning," so called because the finishing or second operation on part of the shape is done in the air, thus avoiding the use of a sectional or split chuck. The shell shown is about 5½ inches in diameter. The first or breaking-down chuck is shown at *A*. The neck or small part of the piece, and also a portion of the spherical surface, is formed by the spinning tool without any support from the chuck. After the shell is spun, or broken down on chuck *A*, it is annealed and pickled. It is then put back on chuck *A* and planished or hardened on the part that is to retain its present shape. The work is then placed on the chuck *B* and the soft part is manipulated by the tool until it conforms to the shape shown to the right. While this soft part of the metal is being formed, the part which was previously hardened retains its shape.

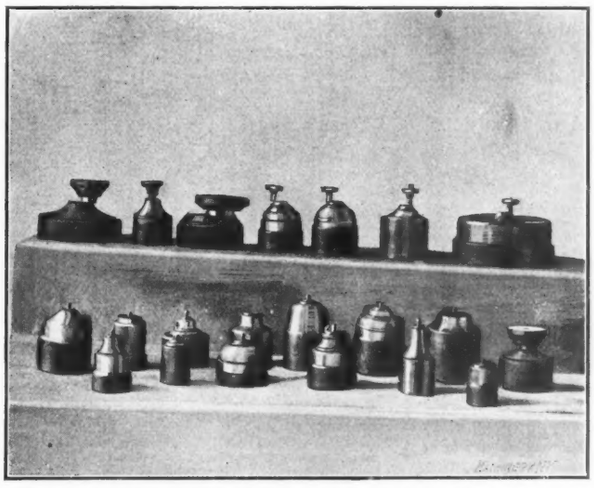


Fig. 11. Another Group of Spinning Chucks. Those in the Upper Row are of the Split or Key Type

Various Types of Metal-spinning Chucks and Their Construction

A miscellaneous collection of spinning chucks is shown in Fig. 10. As will be seen, the larger ones are machined out in the back to lighten them, and also to give them an even balance. The larger of those illustrated measure about 9½ inches in diameter, and they are made of cast iron, while the smaller chucks shown in this view are of machine steel. The chuck marked *A* is a key chuck. Another collection of spinning chucks of various shapes is shown in Fig. 11. Those in the upper row are all key or split chucks, and the keys are shown withdrawn from the sockets. All these chucks, up to 6 inches in diameter, are made of machine steel; those

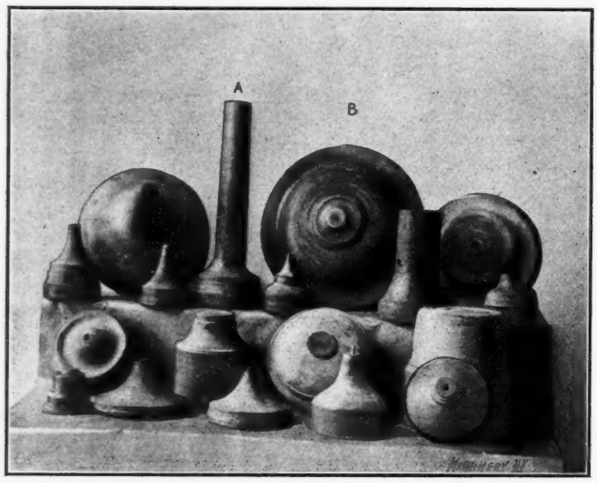


Fig 12. Various Forms of Spinning Chucks made from Hard Maple

seen in the lower row are shapes which are comparatively easy to spin.

A collection of hard maple chucks is shown in Fig. 12, some of which represent shapes that are difficult to spin. The chuck *A* is 15 inches long, and the maximum diameter of *B* is 12½ inches. These figures will serve to give an idea of the proportions of the other chucks. All of the chucks shown have threads cut in them and they are screwed directly to the spindle of the lathe, the faceplate being dispensed with. Some of the larger wooden chucks used measure approximately 5 feet in diameter. A chuck of this size is built up of sections which are glued together.

A number of bronze sectional split chucks are shown in Fig. 13. When spinning over a sectional chuck, it is first

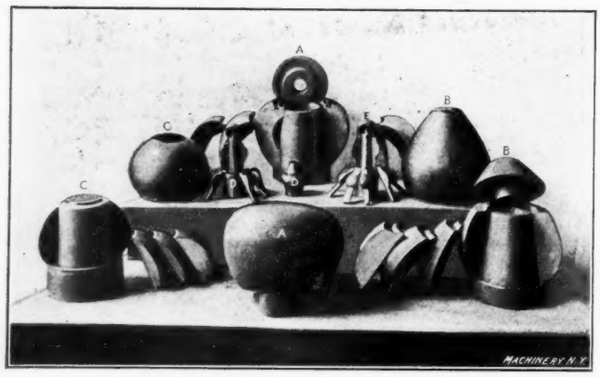


Fig. 13. A Group of Bronze Sectional Chucks

necessary to break down the shell as far as is practicable on a solid chuck. Care should be taken, however, to leave sufficient clearance so that the work may be withdrawn. The shell is then annealed, after which it is put on the sectional chuck and the under cut or small end is spun down to the chuck surface. When the entire surface of the shell is spun down to a bearing, the shell is planished or skimmed to a smooth surface; the open edge is also trimmed even and the shell is polished with emery cloth.

A large bronze chuck of seven sections, one of which is a key section, is shown at *A*. The largest diameter of this chuck is 10 inches. It has a cast iron center hub and a steel cap at the top for holding the sections in place. This cap, when in place in the retaining groove shown, is flush with the top of the chuck. Another large chuck having five sections and one key section is shown at *B*. The retaining cap in this case is of a different form. The lower part of the sections of all these chucks fit in a groove at the bottom of the hub. A chuck of five sections, that is without a binding cap, is shown at *C*. This is not a good design as the hub or center is too straight, and all of the grip or drive is from the bottom groove, which is not sufficient. The shape shown at *D* is more difficult to spin than any of the others, as it is smaller at the opening in proportion to its size. This chuck also requires more sections in order that it may be withdrawn from the shell after the latter is spun. The chuck *E* is intended for a small shell that is also difficult to spin. The drive pins which prevent the segments of the chuck *E* from turning, may be seen projecting from its base. The centering pins at the outer end of chucks *D* and *E* and the binding caps may also be seen. The chuck *A*, because of its size, is hollowed out to reduce the weight. All of these chucks were made for hard service, and they have been used in spinning thousands of shells.

Another group of sectional chucks is shown in Fig. 14. There are mostly made from hard maple. The sections of chuck *A* are planed and fitted together and thin pieces of paper are glued to these sections before they are glued collectively for turning. By using the paper between the joints, the sections may be easily separated after they are turned to the proper size and form. If the different sections were glued without paper between them, the joint formed would be so good that the separation of the sections could not be controlled, and parts from opposite sections would be torn away. The use of the paper, however, between the glued joints, controls the

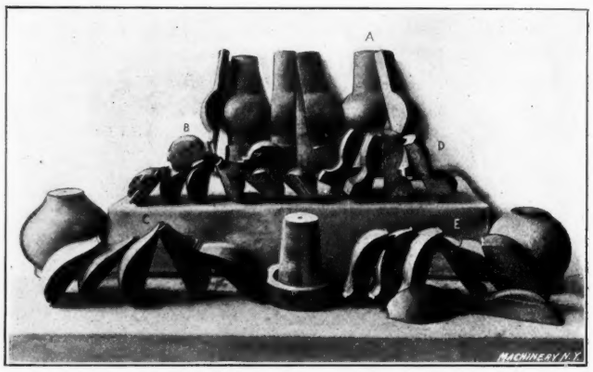


Fig. 14. Sectional Chucks made from Wood

separation of the sections. The chuck shown at *D* is also made with the paper between the sections. Chucks *B* and *E* are turned from the solid, care being taken to have the grain of the wood lengthwise. After they are turned to the required form, they are split into sections with a sharp chisel. Before doing this, the key-section should first be laid out. There should be as few sections as possible, the number being just sufficient to enable the withdrawing of the chuck from the shell after the latter is spun to shape. This method of making a chuck, while quicker than the other, is not good practice, except for small work.

A lignum vitæ chuck is shown at *A* in Fig. 15 that was made with paper between the sections. The key-section is shown on top. This wood, while being more durable than hard maple, costs sixteen cents a pound in the rough and, counting the waste material, is not any cheaper than bronze, and is less durable. The hard maple chucks *B* and *C* were turned from the solid, after which the sections were split. The segments shown in the center of the illustration did not split evenly, owing to a winding or twisting grain.

The construction of a sectional spinning chuck is shown in Fig. 16. This illustration also shows the proper proportion for the central hub and its taper. This hub should never be straight, but should have from 5 to 7½ degrees taper on the central part. There should also be a taper of 1½ degree on the other binding surfaces as indicated. These parts are made tapering so that the shell can be released from the

lathe after spinning, without hammering or driving; when straight surfaces are used the work has to be pried off, and it is also harder to set up the sections for the next shell. Another disadvantage is that with straight fittings the wear cannot be taken up. An end cap or binder should be used wherever possible as it steadies the chuck. A drive pin should also be used and the hole for it drilled in the largest

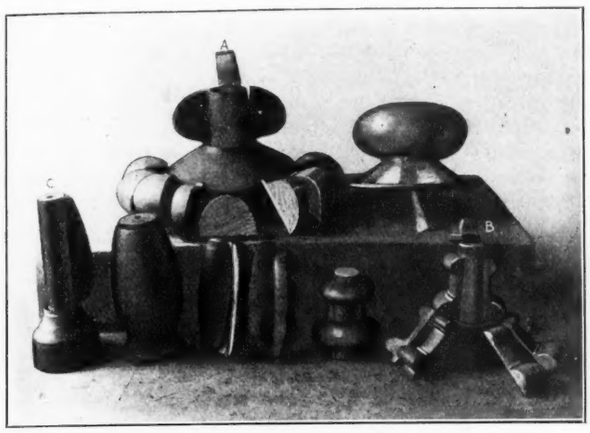


Fig. 15. Other Examples of Wooden Sectional Chucks

section; this is important, as it gives the sections a more positive drive. If they slip they will soon wear themselves loose and leave openings at the joints.

The plan view shows the method of laying out the various sections. The key should be laid out first. One key is enough for the particular form of chuck illustrated, but it is often necessary to use two key sections when the shell opening is small.

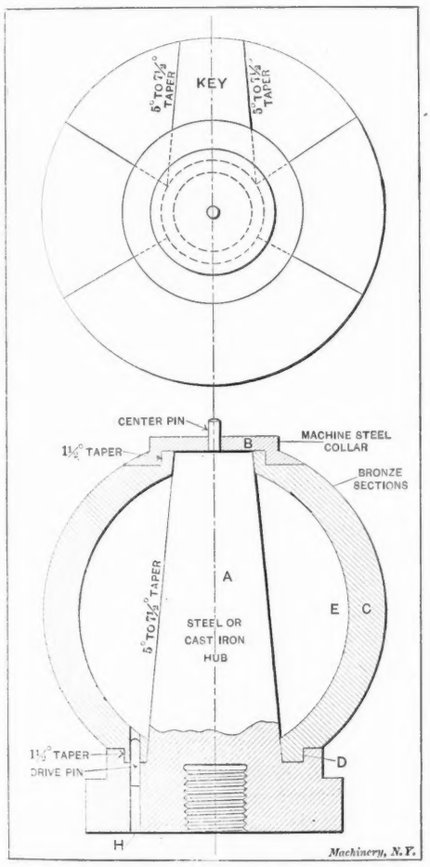


Fig. 16. Elevation and Plan showing Construction of Sectional Chuck

When a sectional chuck is to be made, it is important to decide first on the size of the central hub *A*, the number of sections *C*, and also the design of the cap or binder *B*. This cap must not exceed in size the opening in the finished shell, as it would be impossible to remove it after the chuck sections were taken out. After the size of the hub *A* has been decided upon, a wooden form should be turned that is a duplicate of *A*, except that a spherical surface *E* should be added. This spherical part should be slightly smaller than the inner diameter of the bronze sections in order to allow for machining them. In turning this wooden pattern on which the plaster patterns for the sections are to be formed, the shoulder *D* should be omitted, as a removable metal ring will take its place.

When the wooden hub is ready, two metal partitions or templets of the same outline as the chuck, though about one-half inch larger than its total diameter, for shrinkage and finishing, are fastened to the hub in the correct position for making a plaster pattern for the key section. These patterns should have extension ends so that the sections when cast, may be held by them while they are being turned. The templets should be banked around with a wad of clay, and they should also be coated on the inside with sperm oil to keep the plaster from sticking. There should be two brads driven in the hub for each section of plaster to hold the sections in place while they are being turned. After the plaster for the key section has hardened, the templets should be located, one on each side of the key section, so that the two adjacent sections may be made. In this way all the sections are finished. After about forty-eight hours the plaster will be hard enough to turn in the lathe with a hand tool. The form should be roughly outlined and plenty of stock left for shrinkage, as bronze shrinks considerably. Before taking the sections off the wooden frame, the metal band *D* should be removed to allow the sections to be separated. This should not be done, however, until they are numbered, so that they can be again placed in their proper positions. After the sections are cast, they should be surfaced on a disk grinder, or finished with a file, care being taken to remove as little metal as possible. Each section is next tinned on both contact faces, and then all are assembled and sweated or soldered together by a blow-pipe. It is sometimes necessary to put a couple of strong metal bands around the sections to hold them firmly in place when soldering and also to support them during the turning operation.

The central hub *A* should be machined first; then the assembled outside shell should be machined to fit the hub *A*, both on the taper part and at the point *D*. While the segments are being bored and faced, they are held by the extension ends (not shown) which were provided for this purpose. This outer shell should also be machined all over inside so that it will be in balance. It is then taken out of the chuck and a hole is drilled in the largest section for drive pin *H*. The hub *A* is then caught in the lathe chuck with the assembled sections on it, and a seat is turned for the cap *B*. After this is done the binder bands can be removed, but not before. The chuck can be finished with a hand tool and file after the roughing cut is taken. After the sections are removed from the hub and numbered at the bottom or inner ends, they can be separated by heating them. If the joints are properly fitted there will be only a thin film of solder which can be wiped off when hot.

* * *

A new iron has been produced and sold for a short time past by the American Rolling Mill Co., of Middletown, Ohio. It is a product of the open-hearth steel furnace, but in chemical composition and in mechanical properties it is so closely similar to wrought-iron that the term "steel" can no longer be applied to it properly. The makers have given it the trade name "American Ingot Iron." This ingot iron differs from steel in having its carbon, manganese and silicon contents reduced to small fractions of the amounts found in ordinary soft steel. A typical analysis is as follows: Carbon, 0.02 per cent; manganese, 0.01 per cent; phosphorus, traces; sulphur, 0.02 per cent, and silicon, traces. The metal is to all appearances identical with dead-soft steel, or a good wrought-iron, though its fracture lacks the ropy fiber seen in the latter. Its strength is closely the same as that of wrought-iron. Several tests indicate an ultimate tensile strength of from 47,000 to 49,000 pounds per square inch. Its ductility is remarkably high, and the metal is rolled into sheets and the sheets used for drawing in the drawing press with good results. The prime quality of this ingot iron, however, is its resistance to corrosion. This was the object for which it was originally produced as an experiment, and when trials against steel in sulphuric-acid solutions showed the hope of high corrosion resistance to be borne out, it made the metal at once the most interesting appearance in iron metallurgy of the present time.

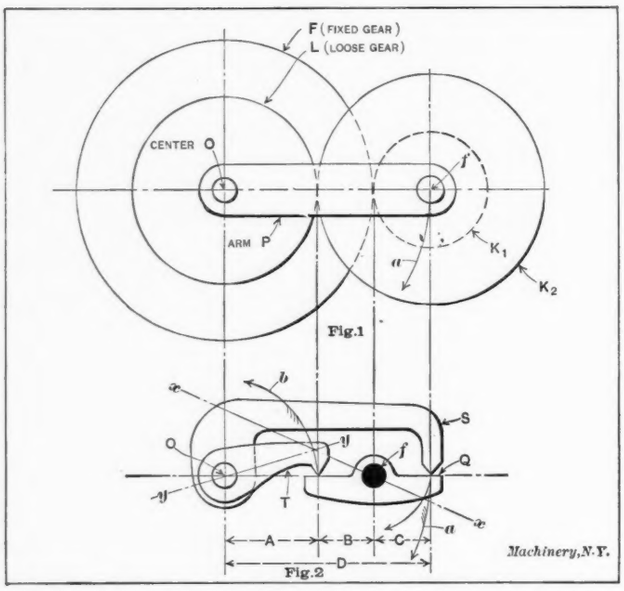
* * *

Don't forget that it is a high point in economy to put all necessary information and data on all drawings.

SOLUTION OF EPICYCLIC GEARING BY THE METHOD OF LEVERS*

By JOHN S. MYERS†

The solution of epicyclic, planetary, or as it is sometimes called, differential gearing, is often rather confusing. This is especially the case to the person who approaches the subject for the first time, and, unless some correct and systematic method be pursued, two different men working independently on the problem are quite likely to get entirely different results as to the velocity ratio, and resultant direction of rotation. The method which is probably most generally known is that of separate motions, and the only drawback to this method is



Figs. 1 and 2. Diagram for the Solution of Problem in Epicyclic Gearing by the Lever Method

the liability of getting the signs (+ and —) mixed.

In the following problems the writer has illustrated the application of this method, at the same time applying a method which he has termed *the lever method*, in each case checking the latter by the former to prove the work.

The principal advantages of the lever method are: 1. That the resultant direction of rotation can be determined without calculation by a simple process of inspection, thereby reducing the chances of error to a minimum, and offering a ready means of checking the result obtained by some other method. 2. It facilitates finding the directions and amounts of the tooth pressures.

When applying the lever method for velocity ratios, instead of taking the actual radii of the various gears, these radii may be taken as the number of teeth in the respective gears if all the gears in the train are of the same pitch. If the gears are not all of the same pitch, take the number of teeth equivalent if they were all of the same pitch. For example, if in Fig. 1 the gears F and K_1 are 1-inch pitch and have 40 and 20 teeth, respectively, while gears L and K_2 are ¾-inch pitch and have 48 and 32 teeth respectively, we could reduce them all to the equivalent number of teeth at 1-inch pitch; when the number of teeth in L would be $\frac{3}{4} \times 48 = 36$, and in K_2, $\frac{3}{4} \times 32 = 24$. We would then consider these numbers as the radii of the respective gears. This eliminates slight errors due to dropping decimals when working out an actual pitch diameter and using it in the equations for velocity ratios.

Examples of Planetary or Epicyclic Gearing

In Fig. 1 is shown a train of planetary gears, in which F is the fixed or stationary gear, sometimes termed the sun-wheel. K_1 and K_2 are the planetary gears which are keyed together and rotate about the center f at the same time as they are rotated bodily about the center O in the direction indicated by the arrow a, the arm P actuating the motion. The gear L is free to turn on its axis.

Problem 1.—*a*. What is the direction of rotation of gear L? *b*. What is the angular velocity of gear L as compared to that of arm P? ....

a. For a small fraction of a revolution, the action of a lever and a gear are similar, as far as direction and velocity ratios are concerned. Hence we may replace the gears and the arm P by a system of levers as shown in Fig. 2. The teeth of the fixed gear will always constitute the fulcrum of one of the levers, corresponding to the fulcrum f of lever Q in Fig. 2. The arm P in Fig 1 corresponds to the lever S in Fig. 2, while gear L corresponds to lever T, and gears K_1 and K_2 to lever Q.

Now assume that motion is imparted to lever S in the direction indicated by the arrow a; then lever Q will be inclined in the direction indicated by the line xx and being in contact with lever T it will cause this lever to move to the position indicated by the line yy, or to rotate in the direction of the arrow b. This arrow then shows the direction of rotation of gear L, which was to be determined. The answer to question (*a*) is, therefore, that gear L rotates in a direction opposite to that of arm P. This answer is arrived at by a very simple process, thus presenting the minimum chance of error.

b. It is now required that we find the ratio of the angular velocity of gear L to that of arm P. Referring to Fig. 2, we find that if lever S made one complete revolution, the end in contact with Q would move a distance equal to $2\pi D$, and consequently cause that end of lever Q which is in contact with lever T to impart motion to the latter lever, the amount of which would be $\frac{2\pi DB}{C}$

One turn of lever T would require this end to be moved a distance of $2\pi A$. It, therefore, revolves, for one turn of S, a number of revolutions equal to $\frac{2\pi DB}{C \times 2\pi A} = \frac{BD}{AC}$.

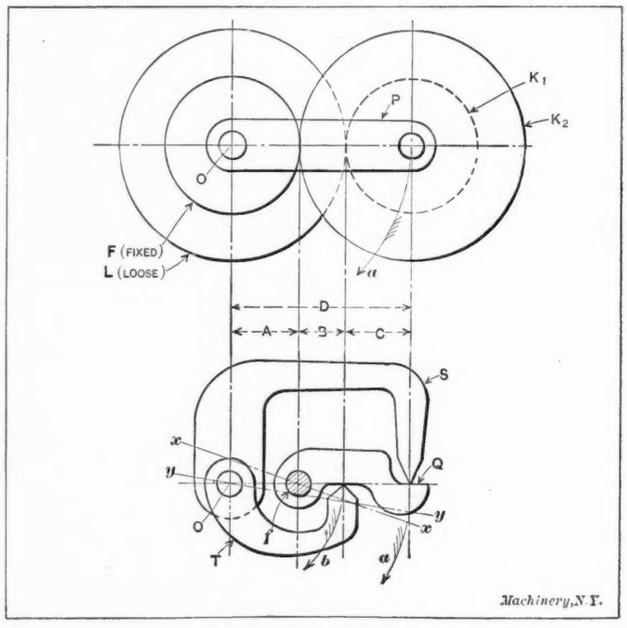


Fig. 3. Diagram for Problem 2

The gear ratio may therefore be stated thus:

Revolutions of P : revolutions L : : $1 : \frac{BD}{AC}$;

or since P is the driving and L the driven member, we would say that the gear reduction is $1 \div \frac{BD}{AC}$, or simply $\frac{AC}{BD}$. If this quantity be less than unity it indicates an inverse speed reduction.

The results obtained may be verified by a common method of separate motions. First lock the gears together and turn the entire mechanism one revolution to the right; call this direction positive (+).

* For additional information on epicyclic gearing, see the following articles previously published in MACHINERY: Epicyclic Gearing, August, 1899; May, 1900, and August, 1900; and Some Applications of Epicyclic Gearing, September, 1900. See also MACHINERY's Data Sheet No. 102, Simple and Compound Epicyclic Trains.

† Address: 2456 Almond St., Philadelphia, Pa.

Second, hold arm P stationary and turn gear F back one turn in the negative (—) direction. The net or combined result on gear F is zero, or "no motion," while for gear L we have:

1st condition: Revolutions of $L = +1$.

2nd condition: Revolutions of $L = -1 \times \frac{A+B}{C} \times \frac{B+C}{A}$

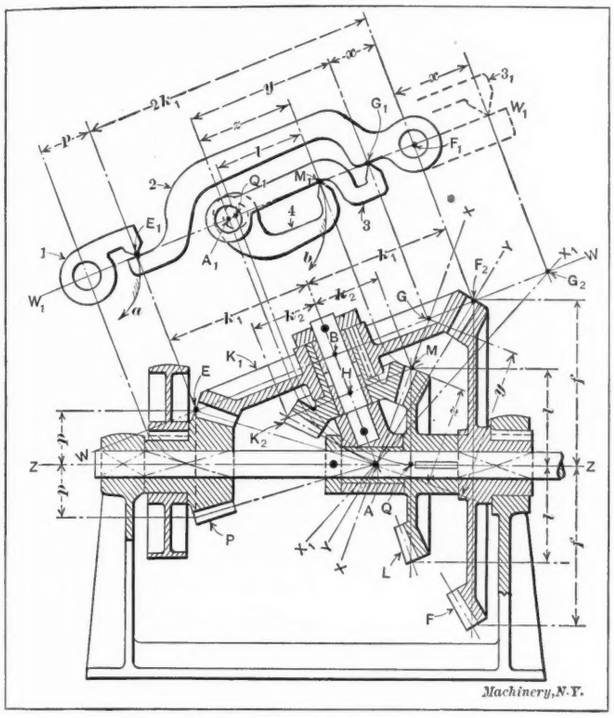


Fig. 4. Compound Bevel Gear Epicyclic Train

Adding these results, we have the number of revolutions of gear L for one positive (+) turn of arm P:

$$1 - \frac{(A+B)\ (B+C)}{AC} = -\frac{B\ (A+B+C)}{AC}$$

and since $A+B+C=D$, the number of revolutions $= -\frac{BD}{AC}$, which is the same result as that obtained by the lever method, the minus sign only serving to show the direction of rotation of L, which is opposite to that of P.

Problem 2.—In Fig. 3 the small gear F is fixed and the larger gear L loose. Arrow a indicates the direction of motion of arm P, while arrow b shows the direction of rotation of the driven wheel L, or lever T, which for this case is the same as the direction of driver P. By the method of levers the revolutions of L for one revolution of P equals

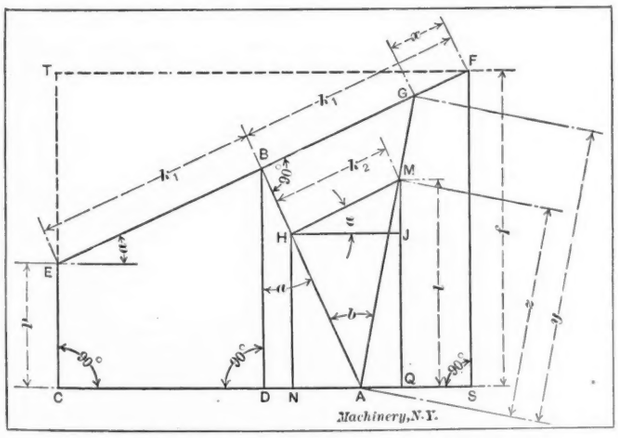


Fig. 5. Diagram for the Solution of Epicyclic Train in Fig. 4

$$\frac{2\pi BD}{(B+C)\times 2\pi(A+B)} = \frac{BD}{B\ (A+B+C)+AC} = \frac{BD}{BD+AC}$$

By the usual method of separate motions we would have the number of revolutions of $L =$

$$1 - \frac{AC}{(B+C)\ (A+B)} = \frac{B\ (A+B+C)}{B\ (A+B+C)+AC} = \frac{BD}{BD+AC},$$

thus showing that both methods are correct analyses of the conditions, as they both give the same results.

Compound Bevel Gear Epicyclic Train

In the train of bevel gearing shown in Fig. 4, P is the prime mover, L is the loose or driven gear, K_1 and K_2 are keyed together, and F is fixed. The action of gears P, K_1, K_2, and L is represented by levers 1, 2, 3 and 4 respectively. Point F_2 of gear F constitutes the fulcrum F_1 of lever 2. Points A and Q are projected upon line W_1W_1 at A_1 and Q_1. These points (A_1 and Q_1) form the fulcrums of levers 3 and 4, respectively.

Now let:

T_P = any given number of revolutions of gear P,

T_L = resulting revolutions of gear L,

$R = \frac{T_P}{T_L}$ = gear reduction of entire train.

By reference to the leverage diagram it is seen that if gear P rotates in the direction of arrow a, gear L will rotate in the direction indicated by arrow b. Gears P and L thus rotate in the same direction. We further have, by the principle of levers:

$$T_L = T_P \frac{2\pi p x z}{2 k_1 y\, 2\pi l} = T_P \frac{p x z}{2 k_1 l y} \qquad (1)$$

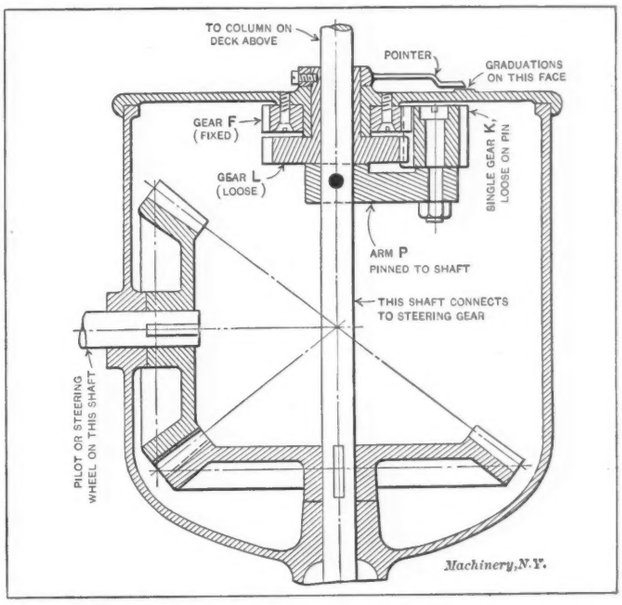

TO COLUMN ON DECK ABOVE
POINTER
GRADUATIONS ON THIS FACE
GEAR F (FIXED)
GEAR L (LOOSE)
SINGLE GEAR K2 LOOSE ON PIN
ARM P PINNED TO SHAFT
THIS SHAFT CONNECTS TO STEERING GEAR
PILOT OR STEERING WHEEL ON THIS SHAFT
Machinery,N.Y.

Fig. 6. Planetary Geared Indicator used on Steering Columns

It can be shown by the principles of geometry (see below) that

$$\frac{x z}{y} = \frac{2 k_1 l - 2 k_2 f}{f+p} \qquad (2)$$

Then

$$T_L = \frac{T_P p}{k_1 l}\left(\frac{k_1 l - k_2 f}{f+p}\right) \qquad (3)$$

from which

$$R = \frac{T_P}{T_L} = \frac{k_1 l}{p}\left(\frac{f+p}{k_1 l - k_2 f}\right) \qquad (4)$$

The results obtained may be verified by the method of separate motions as follows:

First: turn the entire mechanism + 1 turn (arm locked).

Second: hold arm, and turn F back — 1 turn.

1st condition { revolutions of $P = +1$; revolutions of $L = +1$

2nd condition { revolutions of $P = +\frac{f}{p}$; revolutions of $L = -\frac{f k_2}{k_1 l}$

Summing up the results of these two conditions:

$$\text{Revolutions of } P = 1 + \frac{f}{p} = \frac{f+p}{p} = T_P$$

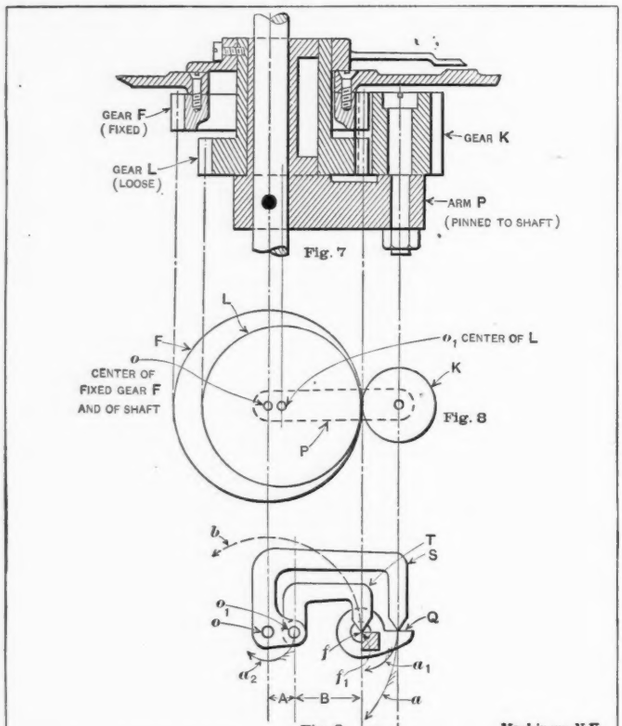
$$\text{Revolutions of } L = 1 - \frac{f k_2}{k_1 l} = \frac{k_1 l - k_2 f}{k_1 l} = T_L$$

Now

$$R = \frac{T_P}{T_L} = \frac{(f+p)\,k_1 l}{p\,(k_1 l - k_2 f)} = \frac{k_1 l}{p}\left(\frac{f+p}{k_1 l - k_2 f}\right)$$

It will be seen that this last equation is the same as equation (4). If the quantity $k_1 l - k_2 f$ is positive, then gear L will revolve in the same direction as gear P. If this quantity is negative, then gear L rotates in a direction opposite to gear P. If, however, this quantity equals zero, then there is no rotation of gear L, no matter what the velocity of gear P is. This is caused by the fact that the gear reduction R is then infinite.

These same deductions can be drawn from an inspection of Fig. 4. If gear K_2 be increased in size, line XX will incline more and more towards line YY, thus increasing the gear ratio in consequence of the decrease in dimension x. When line XX coincides with line YY, point G has been moved to F_2, $x = 0$ and $R =$ infinity, and there is then no motion imparted to gear L. If gear K_2 is further increased until line XX comes into a position outside of line YY, as indicated by X_1X_1, then the dimension x becomes negative, and gear L will rotate in a direction opposite to that of gear P. By the lever method of analysis, this condition becomes at once apparent, for if point G falls outside of point F_2 as at G_2, lever 3 would be located as shown in dotted lines at 3_1. It is seen then that levers 3 and 4 would rotate in a direction opposite to that of lever 1.



Figs. 7, 8 and 9. Diagrams for Solution of Gear shown in Fig. 6

When the shafts are at right angles to each other $f = p$ and

$$R = \frac{T_P}{T_L} = \frac{2 k_1 l}{k_1 l - k_2 p} \qquad (5)$$

The method of obtaining equation (2) may need some further explanation (see Fig. 5).

$$EF = 2k_1;\ ET = f - p;\ BD = \frac{f+p}{2}$$

$$CS = TF = \sqrt{EF^2 - ET^2} = \sqrt{4k_1^2 - (f-p)^2}$$

$$AB = \frac{EF}{CS} BD = \frac{k_1 (f+p)}{\sqrt{4k_1^2 - (f-p)^2}}$$

$$\sin a = \frac{ET}{EF} = \frac{f-p}{2k_1};\quad MJ = k_2 \sin a = \frac{k_2 (f-p)}{2k_1}$$

$$HN = JQ = l - MJ = l - \frac{k_2 (f-p)}{2k_1}$$

$$HA = HN \frac{EF}{CS} = \frac{\left[l - \frac{k_2 (f-p)}{2k_1}\right] 2k_1}{\sqrt{4k_1^2 - (f-p)^2}} = \frac{2k_1 l - k_2 (f-p)}{\sqrt{4k_1^2 - (f-p)^2}}$$

$$\tan b = \frac{k_2}{HA} = \frac{k_2 \sqrt{4k_1^2 - (f-p)^2}}{2k_1 l - k_2 (f-p)}$$

$$BG = AB \tan b = \frac{k_1 k_2 (f+p)}{2k_1 l - k_2 (f-p)}$$

$$x = GF = k_1 - BG = k_1 - \frac{k_1 k_2 (f+p)}{2k_1 l - k_2 (f-p)}$$

We further have

$$\frac{z}{y} = \frac{k_2}{BG} = \frac{k_2 [2k_1 l - k_2 (f-p)]}{k_1 k_2 (f+p)}$$

Then

$$\frac{xz}{y} = \frac{2k_1 l - 2k_2 f}{f+p}$$

Indicator with Planetary Gears as used on Steering Columns

Fig. 6 shows a type of indicator used on steering columns. In practice, gear F may have 36 teeth, gear L, 35, and gear K, 18. Theoretically there should be two different sizes of planetary gears in place of the single gear K, in order that the teeth might mesh properly. In practice, however, the single gear is simpler and entirely satisfactory. In order to apply the method of levers to the solution of this problem, let us conceive of the device as constructed along theoretically correct lines. Fig. 7 shows, in section, a construction which would give theoretically correct results. In Fig. 8 is shown a diagrammatical plan view of Fig. 7, showing the pitch circles of the gears. In Fig. 9 is shown a system of levers which would have the same velocity ratio and the same direction of motion of the lever T as the gears in Fig. 7 would give to gear L. It will be noted that lever Q has one arm of the length C, while the length of the other arm is zero. It, therefore, has no influence upon the velocity ratio. The fulcrum of the lever Q is at f, while f_1 is the fulcrum, or more properly the abutment, of lever T. The end of lever T which is in contact with f_1 is stationary.

Now when lever S is rotated through a small arc in the direction indicated by arrow a, then lever Q is rotated as indicated by arrow a_1 and point o_1 and lever T are moved as indicated by arrow a_2. This movement of point o_1 is equivalent to rotating lever T about the point o_1 in the direction indicated by arrow b. Thus arrow b indicates the direction of rotation of lever T or of the gear L, which corresponds to T.

The ratio of the system of levers in Fig. 9, or of the gearing in Fig. 7, may now be arrived at by the method of levers as follows:

In one revolution of lever S, the point moving along the arrow a_2 would travel a distance equal to $2\pi A$. Dimension A has been shown enlarged in Fig. 9, in order to show the existing conditions more clearly. Now as far as the angular motion of lever T is concerned, we may consider this movement $2\pi A$ to have occurred at the end f in the direction of arrow b, and we may treat point o_1 as the center of rotation, which in fact it is for T or L. One turn of lever T about o_1 would require point f to be moved a distance of $2\pi B$; therefore, a movement of $2\pi A$ would revolve T as many revolutions as $2\pi B$ is contained in $2\pi A$; or, for one turn of lever S, lever T will make $\frac{2\pi A}{2\pi B} = \frac{A}{B}$ revolutions; and since S corresponds to arm P, and T to gear L, we may express the ratio thus:

$$\text{Revolutions of } P : \text{revolutions of } L :: 1 : \frac{A}{B}.$$

Since P is the driver, we may say that the gear reduction is

$$1 \div \frac{A}{B} = \frac{B}{A}.$$

The ratio obtained by the method of separate motions agrees with the above, the final turns of L for + 1 turn of P being $1 - \frac{A+B}{B} = -\frac{A}{B}$, the minus sign indicating that L rotates in a direction opposite to that of P.

It will be noted that in this last problem the method of levers is rather cumbersome to apply, inasmuch as we are compelled to first make a theoretically correct layout, as was done in Fig. 7, before it was possible to solve the problem. The principal value of the method in a case like this may therefore be that of a check on the calculations. But velocity ratios and directions of rotation are not the only features with which the designer must deal. He must also find the tooth loads, pressures of bearings, etc., if he is to intelligently proportion the various parts. This is, in particular, where the lever method aids the designer. It makes it easier to determine the direction and amount of the various tooth and bearing pressures.

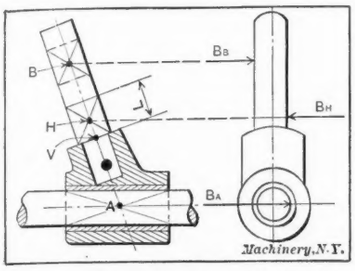


Fig. 10. Diagram for Determining Bending Moments on Main Shaft in Fig. 4

Tooth Loads and Bearing Pressures

Referring now to Fig. 4 let

T_E = tooth load at point E,
T_F = tooth load at point F,
T_M = tooth load at point M,
B_A = load on bearings at point A.

The horsepower and revolutions per minute of gear P being known, the tooth load at E will be found as below (p being in inches and N = revolutions per minute):

$$T_E = \frac{33{,}000 \times \text{H P} \times 12}{2\pi p \times N} \qquad (6)$$

In the system of levers this force T_E acts at point E_1 and has a turning moment about the assumed point G_1 equal to $T_E \times (2k_1 - x)$. The resulting force at F_1 is then:

$$T_F = \frac{T_E\ (2k_1 - x)}{x}. \qquad (7)$$

The tooth load T_M is the force acting at point M_1 in the lever system. Taking the moment of T_E about the point F_1 and dividing by x gave the force acting at point G_1. Taking the moment of this force about point A_1 and dividing by z will give the force acting at point M_1. Thus:

$$T_M = \frac{T_E \times 2k_1 y}{x z}. \qquad (8)$$

The load on the sleeve or bearing at point A is the force acting at point A_1 in the lever system and is found in a similar manner. Thus:

$$B_A = \frac{T_E \times 2k_1 (y - z)}{x z} \qquad (9)$$

Similarly the force acting on the bearing at point H is (see Fig. 10):

$$B_H = B_A \frac{AB}{BH}. \qquad (10)$$

and at point B

$$B_B = B_A \frac{AH}{BH}. \qquad (11)$$

Bending Moments

The forces T_E T_F T_M and B_A are now known, and the forces B_T and B_U, acting on the main bearings, may now be determined (see Fig. 11). According to the principles of static equilibrium, the algebraic sum of the moments of all the forces about any point must equal zero. Taking moments about point U, and calling all the upward forces positive (+) and all the downward forces negative (—) gives us:

$$T_F \times US - T_M \times UQ + B_A \times UA + T_E \times UC + B_T \times UT = 6$$

or

$$-B_T = \frac{T_F\ US - T_M \times UQ + B_A\ UA + T_E\ UC}{UT} \qquad (12)$$

Taking moments about point T gives us, in the same way,

$$-B_U = \frac{T_E \times TC + B_A \times TA - T_M \times TQ + T_F\ TS}{TU} \qquad (13)$$

When inserting the actual values and solving for B_T or B_U, if the sign is +, the force acts upwards, and if the sign is —, the force acts downwards, as indicated in Fig. 11.

All the external forces now being known, the bending moments at the various points may be determined. Before doing so, it is well to apply the principle of static equilibrium as a check on the values of B_T and B_U. The algebraic sum of all the external forces must equal zero. Thus for the present case:

$$\pm B_T + T_E + B_A - T_M + T_F \pm B_U = 0 \qquad (14)$$

In this formula, as well as in the following, the sign ± in front of B_T and B_U indicates that these quantities are to have their proper sign + or — as determined by inserting the actual values in equations (12) and (13).

For the bending moments in the shaft, the moment at any point is equal to the algebraic sum of the moments of all the forces at one side of the point. Let M_C, M_A, M_Q and M_S be the bending moments in the shaft at the respective points C, A, Q, and S. Then:

$$M_C = \pm B_T \times TC \qquad (15)$$
$$M_A = \pm B_T \times TA - T_E \times CA \qquad (16)$$
$$M_Q = \pm B_U \times UQ + T_F \times SQ \qquad (17)$$
$$M_S = \pm B_U \times US \qquad (18)$$

If the mechanism were actually constructed as shown in Fig. 4, account should also be taken of the belt pull on the driving pulley. There would also be torsion in the shaft from the point Q to some point beyond on the right-hand side (not shown in the engraving) where the power is taken off. These torsional stresses should be combined with the bending stresses and the shaft proportioned for the ideal or combined

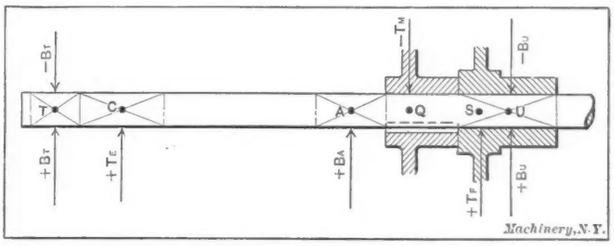


Fig. 11. Diagram for Determining Bending Moments in Stud for Translation Gears in Fig. 4

moment (see MACHINERY, July, 1908, engineering edition, "Maximum Stresses, Combined Torsion and Bending").

Referring again to Fig. 10, if points B and H are the centers of the bushings, and the loads are considered as concentrated at these points, the bending moment at H is

$$M_H = B_A \times AH \qquad (19)$$

More correctly the pressures should be considered as uniformly distributed over the whole length L of the bushing. Then the moment is:

$$M_H = B_A \times AH - \tfrac{1}{2} B_H \times \tfrac{1}{2} L$$

The bending moment at the point V is:

$$M_V = B_A \times AV$$

In all the foregoing calculations, the centers of tooth pressure have been assumed to act at the outside pitch diameters of the gears, which, of course, is not strictly correct. For the moments on the shaft in Fig. 11 the forces T_E, T_M, and T_F should be shifted to about the center of the gear faces.

SLIDE RULE FOR HELICAL SPRING CALCULATIONS

By M. E. DAVIS*

The accompanying illustration is a reproduction of the graduations on a slide rule used for calculations of helical springs. The graduations as shown are, in fact, for two slide rules. They have been reproduced in such a scale that they may be cut out and pasted on a wooden slide rule made similar to the regular calculating rules. If desired, they can be pasted directly on top of the regular scales on ordinary slide rules. They have been used for more than two years in the Ordnance Department drawing-rooms at the Washington Navy Yard, and have been the means of considerable saving in time. The chances for errors are also much less than when calculating directly by the formulas. The method of using the slide rule is easily grasped, even by those who are not familiar with the ordinary type. Those who cannot successfully use spring formulas will have no difficulty with this instrument. If one does not care to cut out the scales and paste them on a slide rule, one can use them to advantage by simulating the movement of the slides by means of measurements taken by a pair of dividers, thus arriving at the same results.

The lower set of scales for the deflection of springs was computed with a torsional modulus of elasticity of 12,600,000. If any other modulus is required, a correction for it is provided on the scale, as will be explained later.

In order to describe the use of the slide rule it is best to take a concrete example. The different scales are designated by letters as indicated below:

A	Stress	
B	Load	Slide
C	Diam. of Wire	
D	Mean Diam. of Spring	

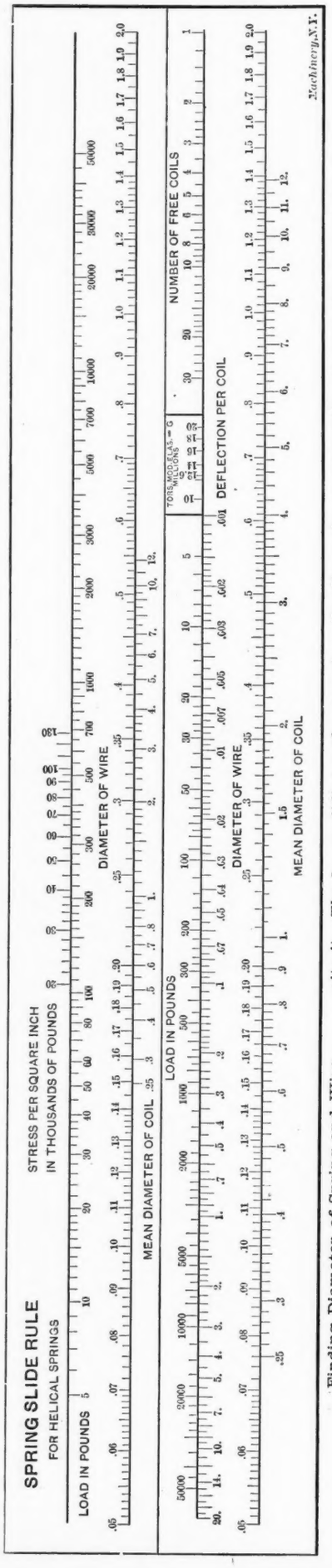
E	Load	
F	Deflection per Coil	Slide
G	Diam. of Wire	
H	Mean Diam. of Spring	

Scales *B* and *C* are mounted on a slide and scales *F* and *G* are also mounted on a slide. All the other scales are on the stationary part of the slide rule or rules.

Assume that the dimensions of a spring which will sustain a load of 250 pounds when the fiber stress in the material is 80,000 pounds per square inch is required. The graduation 250 on scale *B*, giving the load in pounds, is brought opposite the graduation 80 on scale *A*, giving the stress per square inch in thousands of pounds. Scales *C* and *D* now give the diameter of wire and the mean diameter of coil, respectively. It will be seen that there is a series of springs that meets the requirements, the mean diameter of coil being in each case opposite the corresponding diameter of wire. Springs of the dimensions given below will be seen, for instance, to fill the conditions:

Mean Diameter of Spring	Diameter of Wire
1.0	0.200
1.5	0.229
2.0	0.252
2.5	0.271
3.0	0.288
4.0	0.317

Assume that the spring having a mean diameter of 2 inches and a diameter of wire of 0.252 inch, is selected. It is required to find the deflection of this spring under a load of 250 pounds. For this the lower set of scales is used. The graduation 0.252 on scale *G* is brought opposite the graduation 2 on scale *H*; opposite the load 250 on scale *E*, the deflection per coil, in this case 0.315 inch, is read off directly



Finding Diameter of Spring and Wire

To find the dimensions of a spring to carry a given load at a given stress per square inch, first find the given stress in thousands of pounds on the *upper stationary* scale. Bring the graduation for the load in pounds on the *upper sliding* scale opposite it. The *lower sliding* scale now gives the diameter of wire required for a spring having a mean diameter as given by the corresponding graduation on the *lower stationary* scale. It will be seen that there are an indefinite number of possible sizes, but there is always one specific size of wire corresponding to a specific mean diameter.

Example:—Given: Stress per square inch, 80,000 pounds; load, 250 pounds.—Found: Diameter of spring 1.0, and of wire 0.200; or diameter of spring 2.0, and of wire 0.252; or diameter of spring 2.5, and of wire 0.271 inch, etc.

Finding Deflection of Helical Springs

To find the deflection per coil when the load in pounds, the diameter of wire and the mean diameter of spring are known, bring the graduation for the diameter of wire on the *lower sliding* scale opposite the graduation for the mean diameter on the *lower stationary* scale; then the deflection is read off on the *upper sliding* scale opposite the given load in pounds on the *upper stationary* scale. The deflection found is for a modulus of 12,600,000. If the deflection is required for any other modulus, move the slide so that the deflection found comes opposite 12.6 on the small scale marked "Tors. Mod. Elas. = *G*." Then read off, on the upper sliding scale, the deflection for any other modulus opposite this modulus.

Example:—Given: Diameter of spring 2 inches, of wire 0.252.—Found: Deflection for modulus of 12,600,000 equals 0.315; deflection for modulus of 15,000,000 equals 0.264 inch.

* Address: 107 14th St., N. E., Washington, D. C.

on scale *F*. The deflection for any other load can be read off without shifting the slide.

As stated before, the deflection is for a modulus of 12,600,000. If a modulus of 16,000,000 were to be used, a pair of dividers should be set to measure the distance between 12.6 and 16 on the short scale marked "Tors. Mod. Elas. = *G*," and then, by placing one leg of the dividers on the deflection obtained for a modulus of 12,600,000 the deflection for the new modulus, in this case 0.240 inch, will be found at the other point of the dividers, measuring off in the same direction as we measured off from graduation 12.6. The value can also be found directly by bringing the deflection 0.315 opposite the 12.6 graduation on the short scale and reading the new deflection 0.240 opposite the 16 million mark.

[Below the slides in the illustration are shown two sets of directions intended to be pasted on the back of the slide rules, giving in each case in concise language the directions necessary.—EDITOR.]

* * *

IMPROVING THE OUTPUT OF A KEYSEAT CUTTER

During a visit at the shops of the Colburn Machine Tool Co., Franklin, Pa., the superintendent of the firm explained some improvements made in the details of a Colburn keyseating machine, which had greatly improved its output and its accuracy. The improvement in output was estimated by the foreman in charge of the work to be as high as 25 per cent,

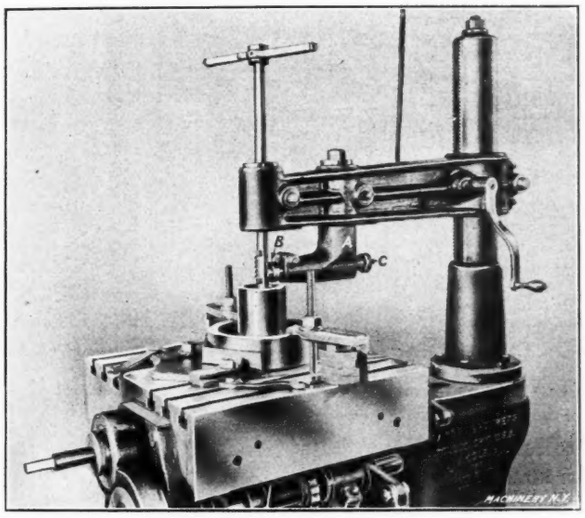


Fig. 1. Colburn Keyseater with Improved Back Support and Multiple Toothed Cutter

taking all classes of work together. The accompanying illustrations show the nature of the changes.

In Fig. 1 the keyseating machine is shown set up ready for work in the hub of a clutch member or similar part. Mechanics familiar with the machine will note the addition of a support for the cutter bar. The overhead supporting arm of this machine is regularly provided with two holes for the bushings through which these bars pass, the one on the outside for large diameter work and one further back for work of smaller diameter. In this case, however, the second hole has been utilized for holding the knee casting *A* for the support. This is provided with an iron back-rest at *B*, set up against the cutter bar by the knurled adjusting screw *C*. Clamp-bolts are provided, as shown, for locking the knee casting in the arm, and the back-rest in the knee.

The advantage of this arrangement lies in giving a backing to the bar close down to the work. The supporting bushing in the arm has of necessity to be raised considerably above the work to permit the cutter to clear, so its support is not as effective as it should be, particularly with a slender cutter bar. When a multiple-tooth cutter is used, as shown, the clearance necessary is considerably increased, so the auxiliary support becomes still more necessary.

Fig. 2 shows the construction of this particular form of cutter bar and cutter, which were also designed in this shop. The bar has two slots milled across it connected by the keyway in which the cutter is set. These slots furnish clearance for the keyway to run out into when it is machined, and at the same time they form solid abutments for the ends of the cutter blade, which has simply to be held from dropping out by a small screw, as shown. By providing a number of cutting edges in a blade, thus firmly bedded in the bar, much more rapid cuts can be taken than with the ordinary single-pointed tool.

As shown in Fig. 2, the first blade that strikes the work has

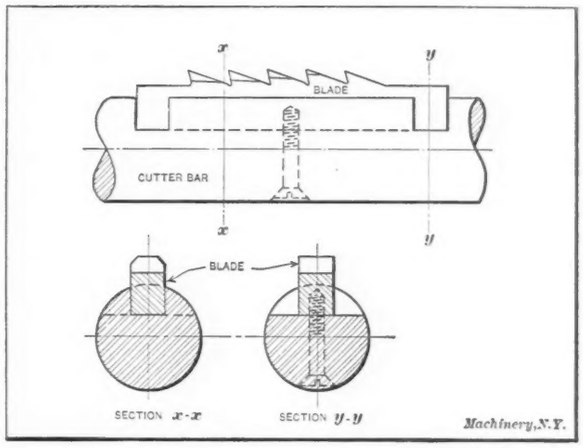


Fig. 2. Details of Multiple Toothed Cutter

the corners well beveled, the next one not quite so much, and so on until the last one, which comes out to sharp corners. This tends to make the tool more durable, as it is only the last cutting edge that gives the finishing shape to the keyway, and this has but a very light cut to take.

Fig. 3 shows how the back-rest is turned around out of the way in removing the work. The cutter bar is withdrawn and the knee casting is loosened and swung around, leaving the table free for the removal and replacing of the work.

The Colburn keyway cutter is, of course, made by the Baker Bros., of Toledo, Ohio, though Mr. L. H. Colburn, of the Colburn Machine Tool Co., was the original inventor. The improvements in the cutter bar and its support, which we have just described, were originated by Mr. B. M. Weller, the superintendent of the latter firm.

* * *

It is stated by the *Scientific American* that Mr. George H. Cove of Somerville, Mass., has constructed a solar-thermo battery which is claimed to produce enough current in ten hours' sunlight to supply thirty tungsten lamps for three days. The apparatus consists of a frame of violet glass, like a large win-

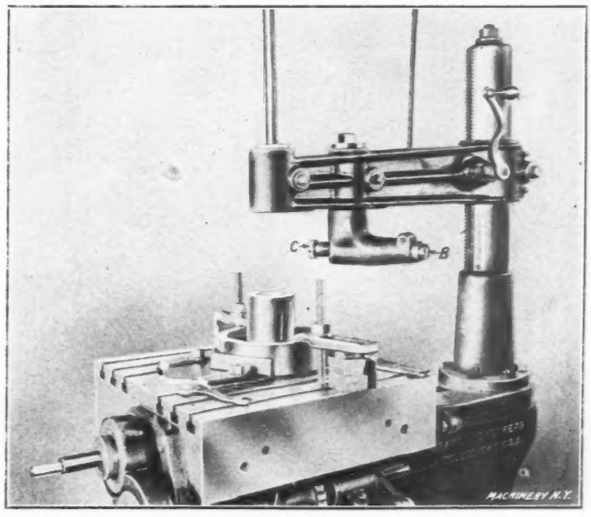


Fig. 3. Support swung back and Cutter raised, to remove Work

dow, below which a number of metallic plugs are set in an insulating material. One end of each plug is constantly exposed to the sun while the other is shaded and cool; the sun's rays thus cause a constant flow of current to the storage batteries.

AIR COMPRESSOR TESTING*

By E. A. FESSENDEN†

Capacities of air compressors are usually stated in terms of the volume of free air compressed per minute or of the volume of air delivered per minute. The capacity of a given compressor may be determined experimentally by several methods among which may be mentioned: (*a*). The displacement method, and (*b*) the orifice method. Since these methods are commonly used, a discussion of them may not be out of place.

The Displacement Method

In its simplest form, the displacement method assumes that the volume swept through by the piston in one minute

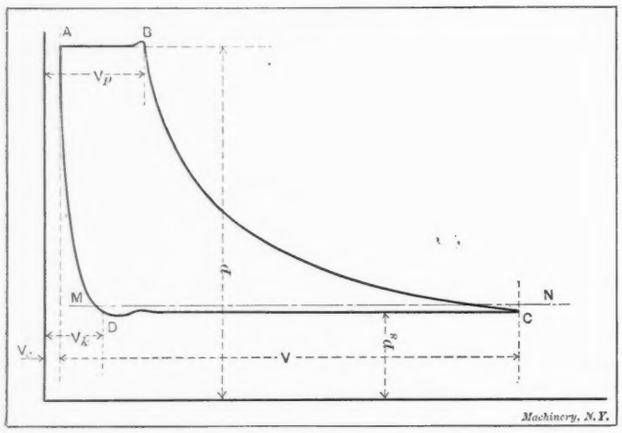


Fig. 1. Typical Air Compressor Diagram

is equal to the volume of free air drawn into the compressor at atmospheric pressure. The formula expressing the capacity under these conditions may be written:

$$Q = \frac{\pi d^2 N s}{4 \times 1728} \qquad (1)$$

where Q = volume swept through by piston in one minute, in cubic feet,
d = diameter of compressor piston, in inches,
s = stroke of compressor, in inches,
N = number of working strokes per minute.

For many purposes this rough method is sufficiently accurate. There are, however, many errors involved in the assumption that the volume of free air drawn into the cylinder is equal to the piston displacement, and these errors make the method unsuitable for accurate work. Before entering into a discussion of the inaccuracies involved in the displacement method together with the means for correcting some of the errors, it may be well to consider briefly the operation of an air compressor.

Fig. 1 represents a typical indicator card from an air compressor cylinder; *MN* is the atmospheric pressure line; the piston displacement is denoted by V and the clearance volume by V_c. During the suction stroke, air is drawn into the cylinder along the suction line *DC*. The pressure p_s inside the cylinder during the suction stroke must necessarily be less than the atmospheric pressure, or there would be no flow of air into the cylinder. At *C* the cylinder is full of air at pressure p_s, and the piston on its return stroke compresses this air along line *CB*. This compression line may be represented by an exponential equation having the form

$$p_1 v_1^n = p_2 v_2^n \qquad (2)$$

The value of n, according to Peabody,‡ may be as low as 1.2 for a "fluid-piston" compressor, and may approach 1.4 when the air is not effectually cooled during compression. A commonly accepted average value is $n = 1.29$. From this equation there results

$$V_p = (V + V_c)\left(\frac{p_s}{p}\right)^{\frac{1}{n}} \qquad (3)$$

as the volume of high pressure air in the cylinder at the point *B*. The valves now open and the air is driven out along the line *BA* until at the end of the stroke, at *A*, only the clearance volume, V_c, is filled with air at the pressure p. On the suction stroke, no air can be drawn into the cylinder until this clearance air has expanded until its pressure drops to p_s, less than atmospheric pressure, thus allowing the suction valves to open. For simplicity, the slight additional drop in pressure indicated by the wavy line at *D*, necessary to overcome the inertia of the suction valves, is disregarded. The volume V_k, of the clearance air expanded to the suction pressure p_s, is given by the equation

$$V_k = V_c\left(\frac{p}{p_s}\right)^{\frac{1}{n}} \qquad (4)$$

so that the volume of the new air in the cylinder at the end of the suction stroke is

$$V_s = V + V_c - V_k$$
$$= V - V_c\left[\left(\frac{p}{p_s}\right)^{\frac{1}{n}} - 1\right] \qquad (5)$$

It is evident that the assumption that the volume of free air drawn into the compressor per minute is equal to the piston displacement could only be true in a cylinder having no clearance volume, and also where the temperature and pressure of the air on the suction side of the piston are the same as the temperature and pressure of the atmosphere. A consideration of the temperature and pressure conditions during the suction stroke will, however, show that the actual volume of free air drawn in per stroke is less than V_s. Moreover, it should be noted that no account is taken of the leakage from the high pressure side of the piston to the low pressure side, nor of the leakage through the valves. The air leaking past the piston to the suction end of the cylinder takes the place of free air that would otherwise be drawn into the cylinder, so that the free air capacity will appear greater than it really is.

In order to cause a flow of air into the suction end of the cylinder, the pressure p_s must be less than atmospheric pressure; therefore, the air expands as its pressure drops in entering the cylinder, and the original volume of the free air drawn in is less than the volume V_s, occupied by this air after it is in the cylinder. Furthermore, the temperature of the air inside the suction end of the cylinder is higher than the atmospheric temperature, since the air is heated as it enters, by contact with the walls of the cylinder left warm by the previous compression stroke. This also causes expansion and still further diminishes the volume of air necessary to be drawn in from the outside to fill the suction space. It is possible to correct the errors due to these temperature and pressure differences by assuming that the air acts as a perfect gas, so that the equation

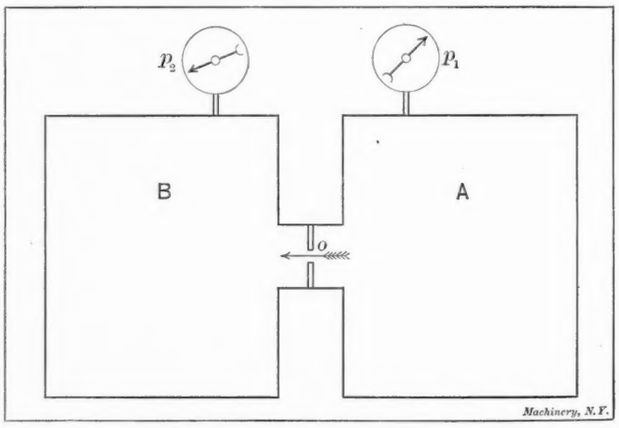


Fig. 2. Illustrating the Flow of Air between Two Reservoirs of Different Pressures

$$\frac{p_a V_a}{T_a} = \frac{p_s V_s}{T_s} \qquad (6)$$

is applicable. In this equation

* See MACHINERY, November, 1909, Engineering edition: Compressor Designing—The Distribution of the Load.

† Assistant Professor of Mechanical Engineering, University of Missouri, Columbia, Missouri.

‡ "Thermodynamics of the Steam Engine," Peabody, 1907 edition, page 361.

p_a = atmospheric pressure in pounds per square inch absolute,
p_s = suction pressure in pounds per square inch absolute, measured from indicator card,
V_a = volume of free air required per stroke, in cubic feet,
V_s = volume of air drawn in after entering cylinder,
T_a = absolute temperature of atmosphere,
T_s = absolute temperature of air in cylinder.

From equation (6) there results

$$V_a = \frac{p_s V_s T_a}{p_a T_s} \qquad (7)$$

It is practically impossible to accurately determine T_s in this equation, but it is probably safe to assume that T_s is about 30 or 40 degrees higher than T_a.

If the value of V_s from equation (5) is substituted in equation (7) there results

$$V_a = \frac{p_s T_a}{p_a T_s}\left\{ V - V_c\left[\left(\frac{p}{p_s}\right)^{\frac{1}{n}} - 1\right]\right\} \qquad (8)$$

The clearance volume is usually expressed as percentage of the piston displacement, *i. e.*,

$$V_c = \frac{V}{m} \qquad (9)$$

which, substituted in equation (8) gives

$$V_a = \frac{p_s T_a}{p_a T_s}\left\{1 - \frac{1}{m}\left[\left(\frac{p}{p_s}\right)^{\frac{1}{n}} - 1\right]\right\} V \qquad (10)$$

The free air capacity in cubic feet per minute for a given compressor is expressed by the formula

$$Q_1 = \frac{\pi d^2 N s}{4 \times 1728} \times \frac{p_s T_a}{p_a T_s}\left\{1 - \frac{1}{m}\left[\left(\frac{p}{p_s}\right)^{\frac{1}{n}} - 1\right]\right\} \qquad (11)$$

which is the same as equation (1) with corrections applied for clearance volume, and temperature and pressure of suction. Equation (11) may be corrected for leakage by introducing the factor $(1-k)$, where k represents the per cent of air leaking past the piston, so that finally

$$Q = (1-k)\frac{\pi d^2 N s}{4 \times 1728} \times \frac{p_s T_a}{p_a T_s}\left\{1 - \frac{1}{m}\left[\left(\frac{p}{p_s}\right)^{\frac{1}{n}} - 1\right]\right\} \qquad (12)$$

Equation (11) gives the free air capacity in cubic feet per minute of any air compressor if we could assume that there were no leakage of air past the piston and valves. This assumption can never be true, and equation (12) is an attempt to correct it. No very close approximation of the value of k, representing the amount of leakage, is possible, since the amount of this leakage is wholly dependent upon the perfection of fit of piston and valves, and this, in turn, is dependent upon the wearing qualities of the materials used in making the compressor and upon the workmanship. Furthermore, the quantities T_s and n in the equation cannot be determined with great accuracy.

The volume of air delivered by the compressor may be obtained from the free air capacity, by assuming that the air acts as a perfect gas and substituting in the formula

$$\frac{p V_d}{T_d} = \frac{p_a V_a}{T_a}$$

$$V_d = \frac{p_a V_a T_d}{T_a p}$$

$$Q_d = (1-k)\frac{\pi d^2 N s}{4 \times 1728} \times \frac{p_s T_d}{p T_s}\left\{1 - \frac{1}{m}\left[\left(\frac{p}{p_s}\right)^{\frac{1}{n}} - 1\right]\right\} \qquad (13)$$

The displacement method, while it cannot be made entirely accurate with the data now at our command, possesses the advantage that it offers a ready method of quickly estimating the capacity of a compressor with reasonable accuracy without making an elaborate test. It may be applied to multi-stage compressors, in which case the volumes of the low-pressure cylinder alone are concerned in the determination of the free air capacity.

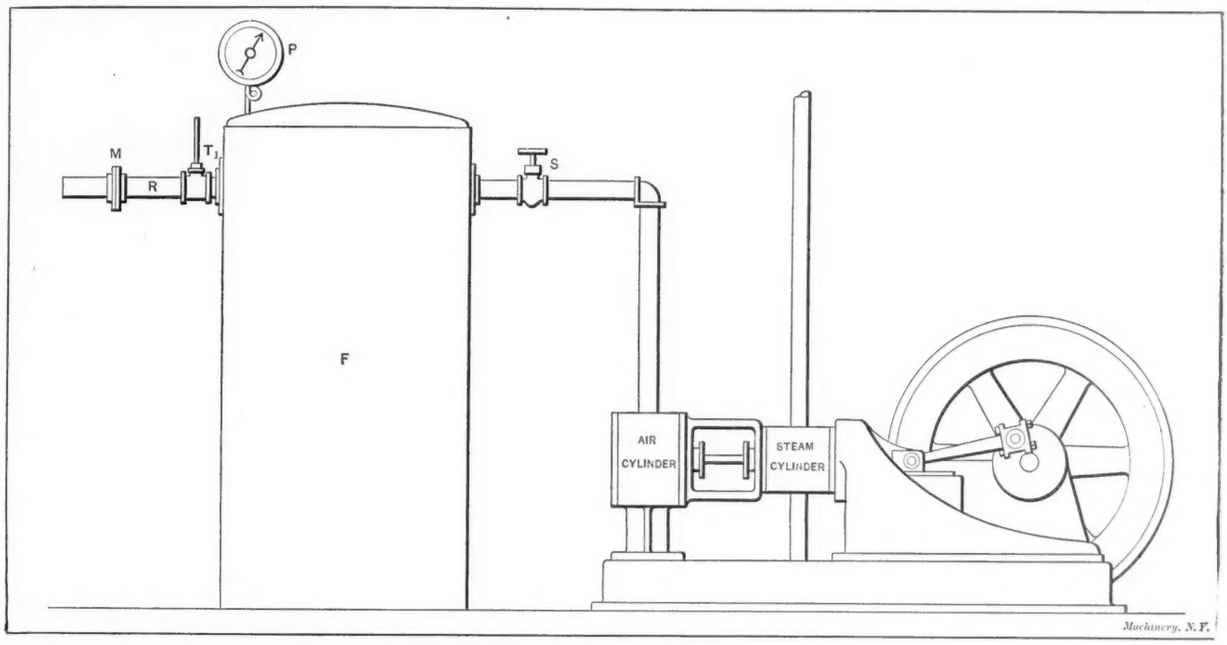


Fig. 3. Air Compressor and Tank arranged for Testing Capacity

The Orifice Method

In Fig. 2, if a gas is allowed to pass from a vessel A in which the pressure p_1 is high, through a small opening o into a vessel B, where the pressure p_2 is low, it is evident that the volume of gas passing through o in one minute is constant as long as the pressures p_1 and p_2 are unchanged. If desired, the vessel B can be discarded, in which case the gas is allowed to discharge directly into the air, and p_2 becomes the atmospheric pressure p_a. This principle has been thoroughly investigated, and is used as the basis of many methods of measuring both gases and liquids. In all of these orifice methods the volume of air, gas or liquid actually passing through the orifice is measured. Hence, in applying them to testing they take into account all losses due to friction, leakage or other causes in the machine being tested.

Fliegner* has shown experimentally that for a vessel discharging directly into the atmosphere, the rate of discharge is directly dependent upon the pressure p_1 so long as p_1 is more than twice the atmospheric pressure. The results of his experiments have been confirmed by Zeuner and Weisbach. The following equations express the relations deduced from these experiments:

* *Der Civilingenieure*, vol. xx. p. 14.

When p_1 is greater than $2p_a$:

$$w = 0.530\, a\, \frac{p_1}{\sqrt{T_1}} \qquad (14)$$

When p_1 is less than $2p_a$:

$$w = 1.06\, a \sqrt{\frac{p_a\,(p_1 - p_a)}{T_1}} \qquad (14a)$$

in which p_1 = absolute pressure in reservoir in pounds per square inch,
p_a = absolute pressure of atmosphere in pounds per square inch,
T_1 = absolute temperature of air in reservoir, degrees F.,
a = area of orifice in square inches,
w = weight of air discharged in pounds per second.

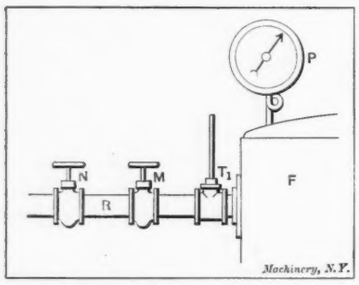


Fig. 4. Arrangement for Testing Capacity by a Modification of the Method shown in Fig. 3

Fig. 3 shows an air compressor arranged for testing by this method. The compressor discharges into a closed tank F, from which extends a pipe R containing an orifice at M. It is important to note that the discharge orifice should be very carefully constructed. It should be short and polished inside so that the friction losses will be reduced to a minimum. The entrance to the orifice must be well rounded and the cross section, preferably, circular. The diameter of the pipe R should be several times that of the orifice and the size of the orifice should be proportioned to the expected capacity of the compressor. A pressure gage P, and a thermometer inserted in a thermometer cup at T_1 show the pressure p_1 and the temperature T_1 of the air delivered to the orifice. Both gage and thermometer should be carefully calibrated, and the diameter of the orifice determined with a micrometer.

If the compressor is operated so that the pressure shown at P is maintained at the required discharge pressure, the speed of the compressor will be about normal if the orifice has been carefully proportioned. It will then be possible to read all

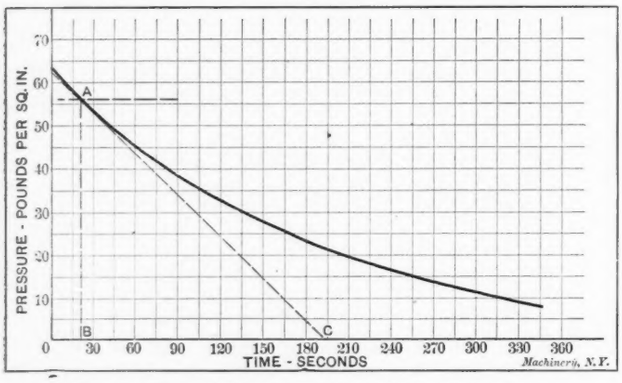


Fig. 5. Diagram plotted from Readings obtained when testing Capacity of Air Compressor

of the quantities required in equation (14), from which the volume of air discharged per minute is

$$Q_d = 60 \times w \times k_d \qquad (15)$$

where k_d = volume of one pound of air at the discharge temperature and pressure.

The value of k_d can be found by finding the volume of one pound of air at atmospheric pressure and at the discharge temperature, from tables published in many handbooks. (See Kent, page 481, 7th ed.); the volume at discharge pressure is then found by the simple rule that the volume of a perfect gas is inversely proportional to the absolute pressure.

Similarly, the volume of free air compressed is

$$Q = 60 \times w \times k_a \qquad (16)$$

in this case k_a being the volume of one pound of air under atmospheric conditions.

The formulas quoted above are for dry air. If much moisture is present a correction will be required for the weight of the water vapor present. This correction is usually disregarded.

Modified Orifice Method

One of the simplest, easiest and most accurate methods of determining the air delivered by a compressor is as follows: The compressor is connected to a receiver tank by an arrangement exactly similar to that shown in Fig. 3, except that an ordinary globe valve replaces the orifice at M, and an additional valve is provided at N as shown in Fig. 4. Since most compressors are furnished equipped with receiver tanks this arrangement should be easily accomplished. The pipe R may be the regular service pipe leading from the receiver. In this case means must be provided for disconnecting this pipe so that the receiver will discharge through the valves M and N directly into the atmosphere. If a receiver is not provided with the compressor equipment, almost any reasonably tight tank capable of holding air at the delivery pressure may be used. The volume should be quite large, the larger the better, and a few slight leaks will not affect the results in any manner whatever.

If it is desired to determine the volume of air delivered by the compressor, it will first be necessary to close off any pipes which may lead from the receiver tank except pipe R which should discharge into the air. Then, with the compressor running at its normal speed, close the valve M until the discharge is throttled down so that the pressure shown at P remains constant at the delivery pressure against which the

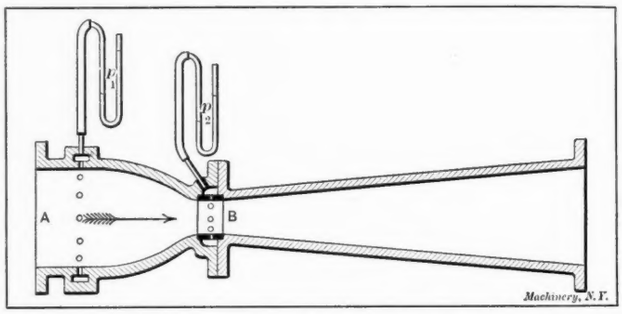


Fig. 6. Venturi Meter for Measuring Flow of Air

compressor is supposed to work. The compressor is now running under its normal working conditions. Now close the valve N tight so that the pressure in the tank rises to a value ten or fifteen pounds higher than the working pressure. Stop the compressor and close the valve S between the tank and compressor so that the tank now stands full of air at a pressure several pounds above the running pressure. Open quickly valve N wide and then take simultaneous readings of time and pressure as the pressure in the tank drops due to the escape of air through the partially opened valve M. This can best be done by two men, one holding a watch (preferably a stop watch) and calling "Read" at short uniform intervals of about fifteen or thirty seconds. The other man should read the pressure shown at P at the instant the signal is given. This should be continued until the pressure has dropped considerably below the working pressure.

Plot the readings just taken, thus obtaining a curve of pressure against time as shown in Fig. 5. (Fig. 5 is the curve taken from an actual test which will be referred to later.) It will also be necessary to determine the volume of the tank, including the piping between valves S and M. This can be done by weighing the amount of water required to fill this volume and then computing the equivalent volume, or the tank volume can be determined by direct calculation.

From the laws of gases we have the general equation

$$p\,V = m\,R\,T \qquad (17)$$

in which p = pressure in pounds per square foot,
V = volume of gas under pressure p, in cubic feet,
m = weight of gas under pressure p, in pounds,
T = absolute temperature in degrees F. of gas,
R = a constant = 53.37 for air.

In the case under consideration, the volume of the tank, V,

and the temperature of the air in the tank are supposed to remain constant. Equation (17) can be rewritten

$$m = \frac{V}{R\,T}\,p \qquad (18)$$

which, differentiated with respect to time gives

$$\frac{d\,m}{d\,t} = \frac{V}{R\,T}\,\frac{d\,p}{d\,t} \qquad (19)$$

in which $\frac{d\,m}{d\,t}$ is the rate of discharge of air in pounds per second. Let A be a point on the pressure-time curve of Fig. 5, corresponding to the working pressure of the compressor, and draw the line $A\,C$ tangent to the curve at A; also draw $A\,B$ parallel to the pressure axis. Then

$$\frac{d\,p}{d\,t} = \frac{A\,B}{B\,C} \qquad (20)$$

in which the values of $A\,B$ and $A\,C$ can be measured directly from the drawing.

It is evident that this method is only a modification of the first orifice method in which the valve M takes the place of the original orifice and the entire apparatus is calibrated at once by the pressure-time curve method. Leaks in the tank will not affect the results since they only serve to increase the area through which the air escapes and the determination is made independent of the area by determining the rate of pressure drop instead. If very accurate results are desired, it would be well to repeat readings for the pressure-time curve and then average the values of $\frac{d\,p}{d\,t}$ obtained.

In recapitulating, the valve M is adjusted to the proper opening to allow just enough air to escape under the working pressure to keep the compressor running steadily at its normal speed and discharging against the normal pressure; then the rate of discharge is found for this pressure and opening. After once adjusting the valve M it must not be moved or changed in any way during the entire test. It is important that the temperature of the air should be the same when the readings for the curve are taken as when the valve M is adjusted. The pressure gage at P must be carefully calibrated.

Example for Practice

As an example of the calculations involved in this method the data for a trial of a small 10 x 7 x 6-inch two-stage compressor are here reproduced. Fig. 5 is the pressure-time curve for this test.

$\frac{p}{144}$ = working pressure in pounds per square inch, absolute,

V = volume of receiver tank = 47.7 cubic feet.

T = temperature of air in tank = 87.1 degrees F. = 546.5 degrees absolute.

From pressure-time curve, Fig. 5, $A\,B = 56 \times 144$ pounds per cubic foot, and $B\,C = 174$ seconds.

The rate of discharge is

$$\frac{d\,m}{d\,t} = \frac{V}{R\,T}\,\frac{d\,p}{d\,t} = \frac{47.7}{53.37 \times 546.5} \times \frac{56 \times 144}{174}$$

$= 0.0758$ pounds per second.

At a pressure of 56 pounds per square inch absolute (42.3 pounds by the gage) and a temperature of 87.1 degrees F. one pound of air has a volume of 3.607 cubic feet. The discharge was therefore

$0.0758 \times 3.607 = 0.2734$ cubic feet per second,
$= 16.404$ cubic feet per minute.

One pound of air at atmospheric pressure and 32 degrees F. occupies 12.387 cubic feet, so that the volume of free air compressed, reduced to freezing point, was

$0.0758 \times 12.387 = 0.9389$ cubic feet per second,
$= 56.334$ cubic feet per minute.

If it be desired to make an economy test of a compressor under its working load it is only necessary to adjust valve M, determine the rate of discharge of air at the desired pressure as indicated above, and then run the compressor continuously while taking the steam consumption readings, allowing it to discharge into the tank, the air escaping through M. As long as the pressure and temperature of the air in the tank are constant, the volume of air flowing through the tank per second will not change. The pressure in the tank depends on the speed of the compressor, and the governor should keep it constant. The temperature of the discharge air depends largely upon the quantity of jacket water used. If this is kept constant in quantity and temperature, and if the machine is allowed to warm up thoroughly before beginning the test, there is no reason why the temperature of the discharge air should change.

The method just outlined has many advantages. It is rapid, simple, theoretically correct, and can be made very accurate in practice; all leakages and friction losses are taken into account; no expensive apparatus or appliances are required, and in many cases not even a change in piping will be necessary; and the manipulations and calculations are simple.

The Venturi Meter Method

The Venturi meter often used for the measurement of the flow of liquids may also be employed to measure the rate of flow of air or other gas, and very satisfactory results have been obtained, especially under conditions involving the measurement of a large volume of air under comparatively low pressure. A Venturi meter is in effect only a contraction in a pipe line with provision made for determining the difference in the static pressure of the moving fluid at the entrance A, Fig. 6, and at the waist or narrowest part B. The total head causing the fluid to flow through the pipe line is made up of "pressure head" and "velocity head," and if there is no friction in the pipe, the sum of these two is constant over all parts of a closed pipe system. The contraction in the pipe causes the velocity to be much higher at B than at A, consequently the velocity head is increased. An increase in the velocity head could only occur at the expense of pressure head, so that the pressure head indicated at B is less than that at A, and the difference in these two pressure heads is a measure of the increase in velocity. Knowing this change in velocity and the cross sectional areas of the pipe at A and B, we can find the velocity at B and from this the volume of fluid passing through the meter in a given time. When the Venturi meter is used for the measurement of water, the formula for the volume passing through the meter per second is

$$Q = \phi\,A_2\,\sqrt{\frac{2\,g\,H}{1 - \left(\frac{A_2}{A_1}\right)^2}} \qquad (21)$$

where Q = volume passing per second in cubic feet,

H = difference in pressure head between A and B measured in feet of water,

A_1 = area of pipe at A in square feet,

A_2 = area of pipe at B in square feet,

ϕ = frictional coefficient, in most cases about 0.96 to 0.98 for usual construction of meter. (Extremes may be 0.95 to 1.00.)

When used to measure gases the derivation of the formula giving the rate of flow is somewhat complicated. The resulting equation is

$$Q = \phi\,A_2\left(\frac{p_2}{p_1}\right)^{\frac{1}{n}}\sqrt{\left(\frac{2\,g\,n\,p_1\,\gamma_1}{n-1}\right)\left[\frac{1 - \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}}{1 - \left(\frac{A_2}{A_1}\right)^2\left(\frac{p_2}{p_1}\right)^{\frac{2}{n}}}\right]} \qquad (22)$$

in which Q = cubic feet of air passing per second,

p_2 = pressure at waist in pounds per square foot,

p_1 = pressure at entrance in pounds per square foot,

n = exponent of v in equation (2); in this case assuming adiabatic expansion, $n = 1.41$,

γ_1 = density of gas (weight of one cubic foot) at pressure p_1,

g = acceleration due to gravity, in feet per second = 32.2,

A_2 = area at waist in square feet,

A_1 = area at entrance in square feet,

ϕ = frictional coefficient. (Usually negligible in a well-made meter.)

When a Venturi meter is used for measuring the flow of a gas or liquid, precautions must be taken to keep the pressure p_1 constant, and the pressures p_1 and p_2 must be measured with great care. For this purpose water columns are best. The meter tube must be smooth and polished inside in order to reduce the friction losses to a minimum. The shape of the tube must be such as to allow the change in velocity between *A* and *B* to be accomplished smoothly and easily with no opportunity for eddies, cross currents or sudden changes in velocity. Venturi meters are sometimes made self-recording so that a continuous record of the volume of gas or liquid passing is available.

* * *

HANGING UP REAMERS, STRAIGHTEDGES, ETC., FOR STORAGE

Figs. 1 and 2 show some of the tools used by the Colburn Machine Tool Co., of Franklin, Pa., and illustrate the way in which they are kept when not in use. Fig. 1 shows a row of heavy line reamers, while Fig. 2 shows a set of straightedges and a test-bar. The notion of hanging these tools up after using is a novel one, so far as we know.

The line reamers shown in Fig. 1 are used for finishing the upper and lower bearings for the spindle in the spindle sleeve of the Colburn boring mill. By reaming these two bearings together, assurance is given that they are concentric; this gives further assurance of a good fit on the spindle, if the latter is finished concentric all over as it should be. The I-bolts by which they are hung are primarily intended for suspending the reamers in the hole to be reamed, by means of a chain-block and tackle having a swivel connection. This is done

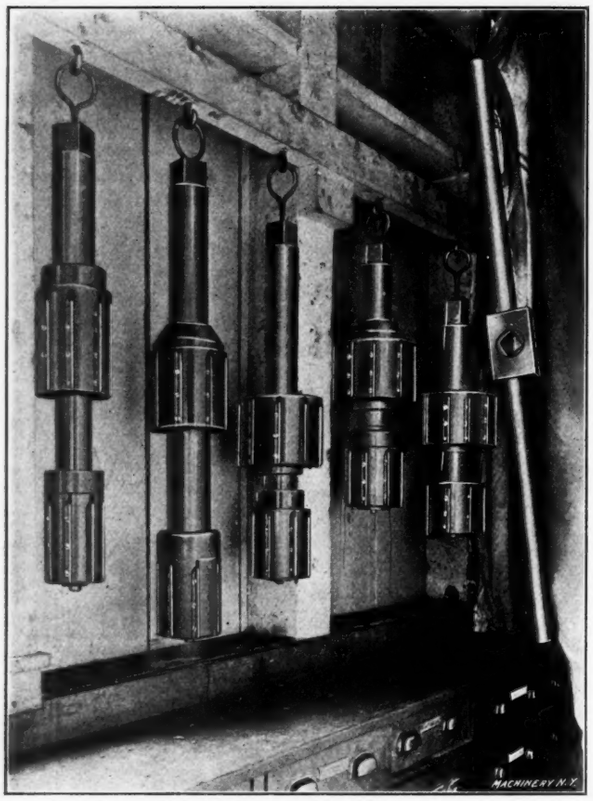


Fig. 1. Large Lining Reamers comfortably hung from Eye-bolts

because the weight of the reamers themselves is so great as to give too heavy a feed, with the very small amount of metal which has to be taken out. The chain-block is employed to lower the reamer gradually while the workmen rotate it.

For turning the reamers, use is made of the double-handled wrench shown at the right of Fig. 1. This is of the ratchet type, with a square socket on the ratchet which fits the squared shanks of the whole line of reamers. By using a ratchet wrench for this, a full revolution is not required, so it is possible to have the handles long enough to be easily manipulated, and still avoid interference with the housings or column of the machine. While the I-bolts were originally intended for use when the reamer is in active operation, as described, this provision naturally suggested hanging them up when they were not in use. When so held they are out of harm's way, as nothing can be laid on top of them and they are kept from contact with each other.

The row of straightedges shown in Fig. 2 is kept at one end of the erecting floor. As shown, a stout cross-beam is mounted on projecting joists, and provided at the top with notches for locating the bent ends of the long hook rods, on which the tools are hung. These grooves space the hook rods evenly and

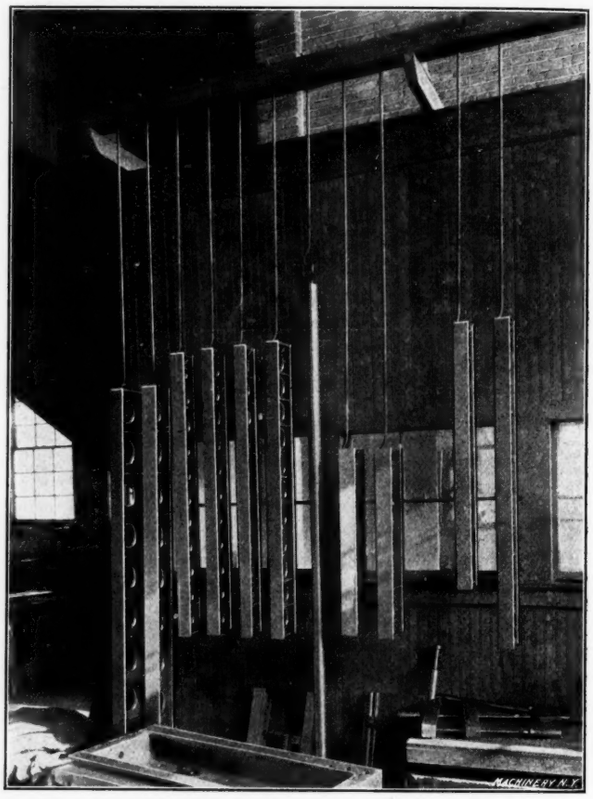


Fig. 2. Suspended Straightedges and Test Arbors, which are thus preserved from Distortion

prevent them from twisting around and dropping out. It might almost be said that these straightedges and test-bars have a *comfortable* look when stored this way. It is said that they preserve their shape better, showing less tendency to warp than when left lying flat in the case as usual. This seems to be a natural position for such tools to take when at rest.

* * *

Electric heat is being employed more and more in the industries. It is, for example, successfully applied in the manufacture of food products. The Natural Food Co. of Niagara Falls manufactures a product called "triscuit," this being a cracker of shredded wheat, baked or toasted by having heat applied on both sides at the same time. The operation consists in passing the product through a machine between two endless belts, enclosed except at the ends. The links of these belts are electric stoves so arranged that the cracker is fed and held pressed between the faces of two of these miniature stoves throughout a complete circuit of the machines. The operation is continuous, and each machine, being provided with about 2,500 stoves, is capable of producing 17,500 triscuits an hour. The company is operating about 10,000 electric stoves, and the failures in operation have been exceedingly small. Another application of electric heat is in the embossing and burning of designs on wood. A form of electric heater is inserted in a hollow cylinder, the outside surface of which has the design engraved on it. The cylinder is slowly revolved, and pieces of soft wood placed between it and a corresponding roller, the wood being fed between the rollers in a manner similar to that of clothes being put through a wringer. In this manner five or six impressions can be burnt per minute.

CIRCULAR FORM AND CUT-OFF TOOLS*—1

PRACTICE FOR THE BROWN & SHARPE SCREW MACHINES

By DOUGLAS T. HAMILTON†

When a screw machine is to be fitted up for the making of any given piece of work, the methods of arranging the operations and the tools to be used should be decided upon before designing the cams. One of the first things to consider is the method of applying the circular form and cut-off tools. These methods, of course, will vary to a considerable extent, according to the shape of the piece to be made.

When Circular Form and Cut-Off Tools can be used to Advantage

Forming with circular tools as shown in Fig. 1, when the piece permits, is usually the best and quickest method; it is quicker than using the turret tools, on account of eliminating the necessity of revolving the turret. The tools can also be easily and quickly changed when setting up for another piece. This method is recommended when the length of the work is not more than 2½ times the smallest diameter of the piece when finished. For example, when the smallest diameter *a* in Fig. 1 is ¼ inch and dimension *b* not more than ⅝ inch, it is most economical to use the form and cut-off method. The operations for making this piece would be as follows: The stock is first fed out to the stop, then the form tool *A* is brought in, forming the body *a*, and just as the tool *A* is finishing, the tool *B* is brought in and severs the piece from the bar. Another example is shown in Fig. 2 where a shouldered

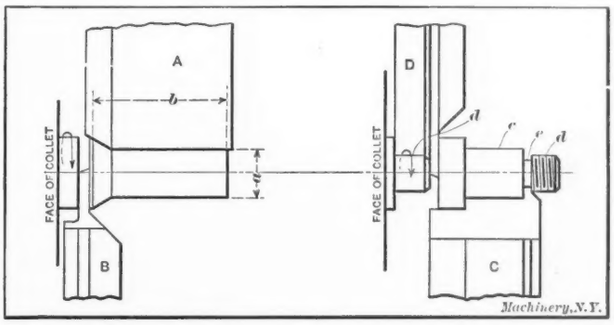


Fig. 1. Illustration showing Relation between Smallest Diameter of Work and Length of Forming Tool

Fig. 2. Illustration showing a Case where the Cut-off Tool forms Part of the Piece

and forms the part *d* for the next screw at the same time; the stock is then fed out to the stop and the operations continued. This order of operations necessitates one complete revolution of the turret, for each screw, and if the time utilized by the tools *C* and *D* is not long enough to allow the turret to be revolved, so as to bring the stop into position for the next piece, extra time would have to be added for revolving the turret.

Applications of Circular Tools

When making short screws similar to that shown at *A*, Fig. 3, where the circular form and cut-off tools finish the screw, except the threading, it is good practice to apply the circular tools as shown, and if the time utilized by the tools is not

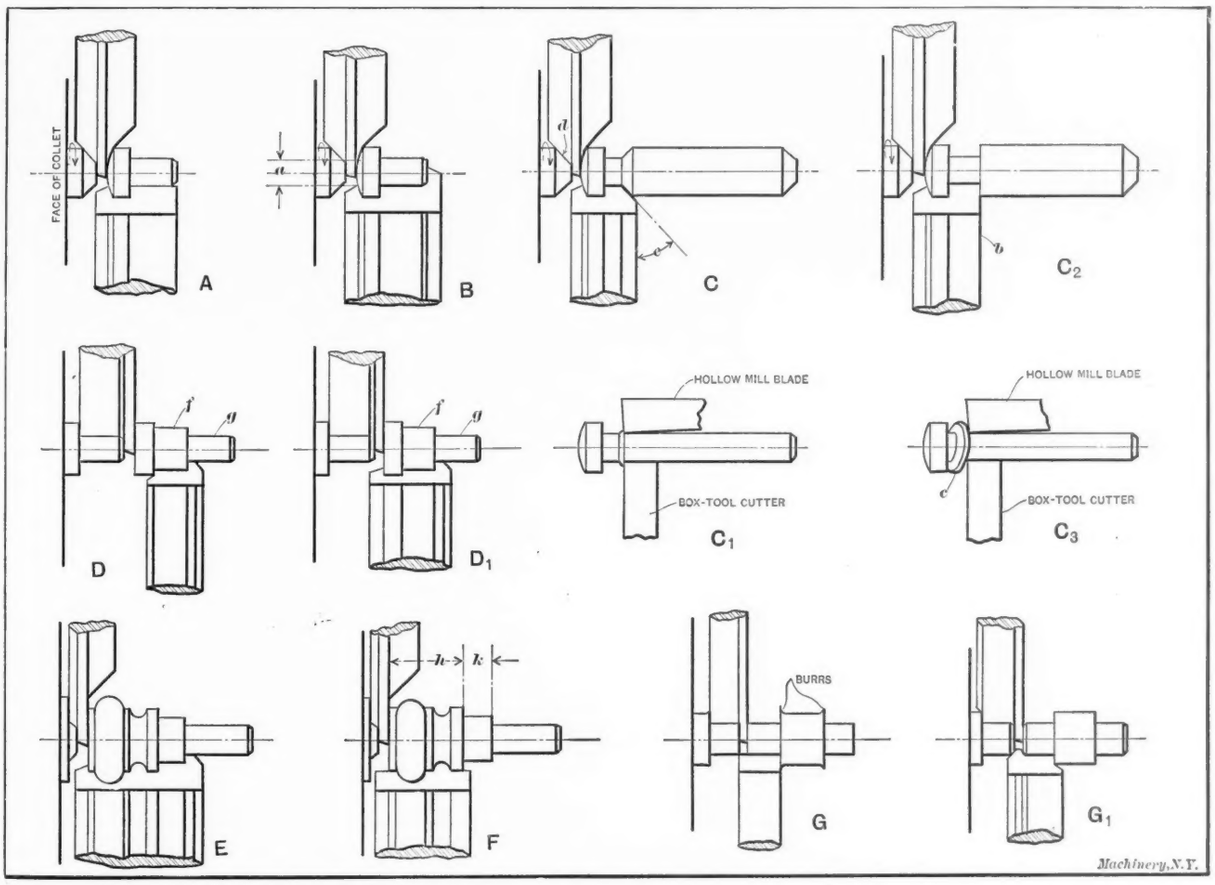


Fig. 3. Examples of Applications of Circular Form and Cut-off Tools

screw is being made; here the tool *C* is brought in and forms the part *c* and the neck *e;* then the die threads the screw, and the tool *D* is brought in and severs the piece from the bar, long enough so the turret can be revolved to bring the stop into position for the next piece, two sets of tools, *viz.*, two stops and two die holders, should be used in the turret. The method shown at *B*, Fig. 3, is not commendable, inasmuch as the feeding of the stock varies to such an extent that the form tool will break off the screw when the latter is much reduced at *a*, in case there be an excessive amount to face off the end of the screw. The turret would also require to be indexed, to clear the slotting arm, so that very little time could be saved by adopting a method of this description, except

* For previous articles on screw machine work, see MACHINERY, September, 1903, Directions for Camming the Brown & Sharpe Automatic Screw Machine; June, 1908, Making Watch Parts in the Commercial Automatic Screw Machine; November, 1908, engineering edition, Attachment for Cutting Squares and Hexagons in Automatic Screw Machines; November, 1908, Some Interesting Automatic Screw Machine Work; April, 1909, Cutting Helical Gears on the Brown & Sharpe Automatic Screw Machine; June and July, 1909, engineering edition, Knurls and Knurling Operations.

† Address: 169 Querbes St., Outremont, Montreal, Canada.

when the part *a* is large in diameter and the screw is short in length. It is, therefore, obvious that a method of this kind should be avoided if possible.

When a box-tool or hollow-mill follows the forming operation, the forming tool should be beveled, as shown at *e* in *C*; this leaves a beveled shoulder on the piece, so that when the box-tool or hollow-mill is fed in as shown at C_1, it completely removes the superfluous material without leaving the objectionable ring which would be produced if the face of the form tool were square, as shown at *b* in C_2. This ring of metal is shown at *c* in C_3; it prevents the finishing box-tool or die

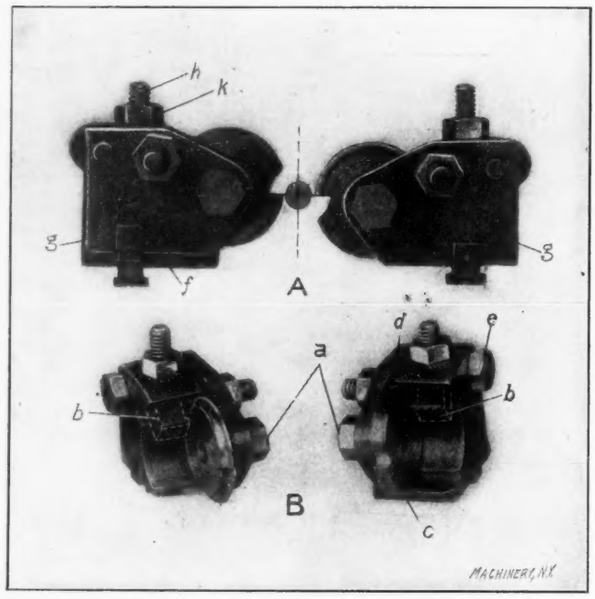


Fig. 4. Holders for Circular Form and Cut-off Tools

from being fed up to the shoulder. It is clearly seen that the ring would have to be removed in any case.

The cut-off tool should bevel the end of the stock, as shown at *d* in *C*, in order to permit the starting of the box-tool on a light cut, until the back rests have a good support; the bevel also locates the hollow-mill and equalizes the cutting pressure on the teeth. The previous examples apply to the making of screws, but the principles involved are also, of course, applicable to the forming of other parts. It is obvious that, as the conditions under which the work is done and the limits allowed on same vary widely, it would be impracticable to lay down hard and fast rules in regard to the application of circular tools, but the following suggestions will be found ap-

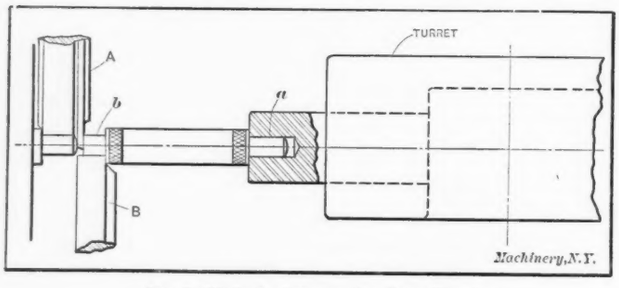


Fig. 5. Method of Supporting Long Work

plicable to general conditions. At *D*, Fig. 3, is shown a method sometimes used to advantage in making shouldered screws or other pieces of a similar character. This forming operation is not recommended when the piece to be made is required to be very accurate, as a slight eccentricity in the spring collet would cause the part *f* to be out of true with the part *g*. In cases where accuracy is required, the part *g* could be roughed down with the cut-off tool and a light finishing cut taken off with a box-tool. At D_1 is shown an improved method of forming the same piece, as the form tool here removes the burr from the head.

In applying circular tools, the question of gaging the pieces must be carefully considered, as in some cases, when difficult shapes are to be formed, it is advisable, if possible, to use the forming tool for this purpose, thus obviating the making of expensive gages, which is usually necessary when more than one tool is used. The piece shown at *E*, Fig. 3, will require a box-tool, forming tool and cut-off tool; if made as shown, it will be seen that no gaging will be necessary, except for diameters and over-all length, the latter not requiring great accuracy. At *F*, a piece of the same shape is shown; three tools are used as before, but the cut-off tool is used to finish part *h* to the required length and the box-tool to finish the shoulder *k* to correct length. It will readily be seen that a more expensive gage will be required for gaging the parts *h* and *k*; considerable time will be lost in setting up the tools, after grinding, in their correct relation to each other, insuring that part *h* be formed the correct length.

It is generally necessary that means should be provided to remove the objectionable burrs thrown up by the forming tools, as shown at *G*, Fig. 3. The burrs are caused by the tools becoming dull and by the rubbing of the forming tools on the sides of the cut due to lack of side clearance on the side of the forming tools. By adding a bevel edge to the tools as shown at G_1, the burrs are removed; this adds slightly to the expense of the tools, but in the majority of cases the results produced warrant the extra expense.

Holding Circular Form and Cut-off Tools

The method by which circular tools are held should be carefully considered; otherwise satisfactory results will not be obtained. If, for instance, the tool-holder is light and improperly supported, chattering will result when long work is

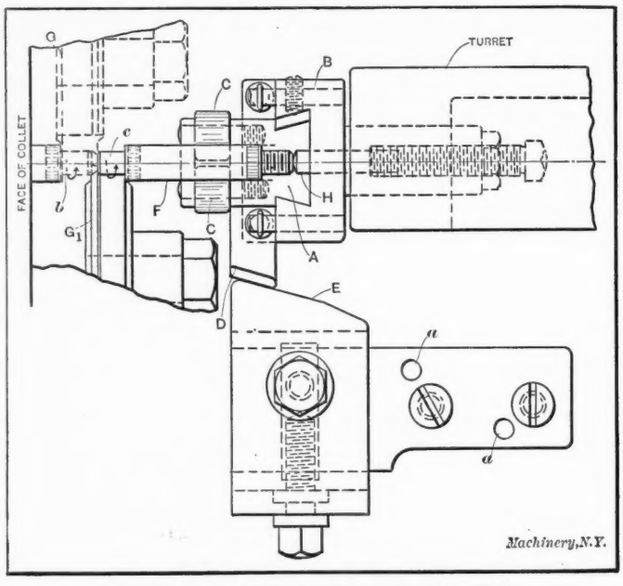


Fig. 6. Improved Method of Supporting Long Work

formed. To prevent this, the tool-holder should be well proportioned and held rigidly upon the cross-slide. The half-tones *A* and *B*, Fig. 4, illustrate a suitable holder for general work, which is supplied by the Brown & Sharpe Mfg. Co. with their various types of automatic screw machines. This holder embodies all the essential features requisite for obtaining good results, *viz.*: rigidity, means to prevent the tool from rotating while cutting, suitable adjustment, provision for periphery clearance, means for adjusting the tool at right angles to the work, and means for the securing of the holder to the cross-slide.

The form tool is firmly clamped against the face of the holder by means of cap-screw *a* and clamping bolt *b*; the latter is used to keep the tool from turning while cutting. Care should be taken when designing the circular tools, so that the clamping bolt *b*, gets an ample bearing on the side of the tool as otherwise the clamping bolt will in time become bent, as shown by the dotted lines in the half-tone *B*, which would impair its efficiency as a clamping device. Plate *d* and eccentric bolt *e* are provided for obtaining a slight adjustment when setting the cutting edge of the tool in the correct relation to the center of the work, as shown at *A*. The block *f* is used for raising the tool when the cutting edge is cut below the cen-

ter. At g are two grub screws, not shown in the half-tone, by means of which the tool can be set at right angles to the work. The holder is clamped to the cross-slide by the bolt h and nut k. Numerous types of holders for holding circular tools have been designed, the principles involved being in most cases similar to those of the one described.

Supporting Long Work while Forming

It is sometimes found necessary to support long work while forming, especially when the piece being formed is turned down on both ends. The work is generally supported by a support held in the turret, which, in the majority of cases, can also be used as a stop. In Fig. 5 is shown a piece which is being supported in this manner. The part a is formed by the tool A and the stock is then fed out into the support

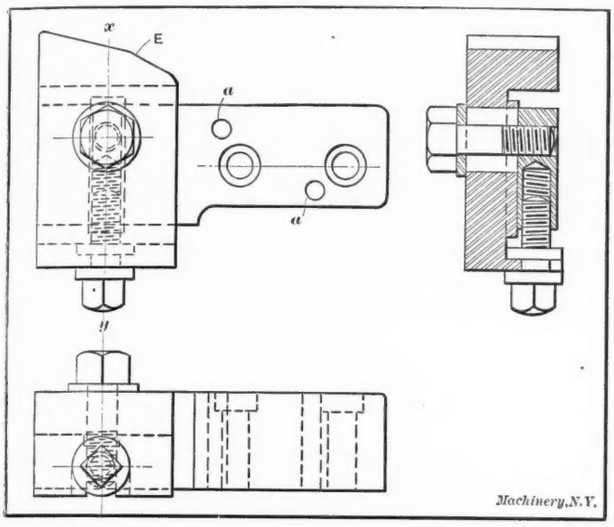


Fig. 7. Cam Attachment used in Connection with the Arrangement for Supporting Long Work shown in Fig. 6

which in this case also acts as a stop; the tool B then forms the part b. This kind of a support works satisfactorily on work which is not required to be very accurate and which is left plain, *i. e.*, not threaded on part a. In some cases both ends would require to be knurled, and then a support of this description could not be used to advantage.

In Fig. 6 is shown a method which will work satisfactorily when the piece is threaded or knurled. The work operated on is shown in position, supported by a movable slide A held in a holder B; slide A carries two hardened and ground supporting rollers C. It is forced up against the work by cam D

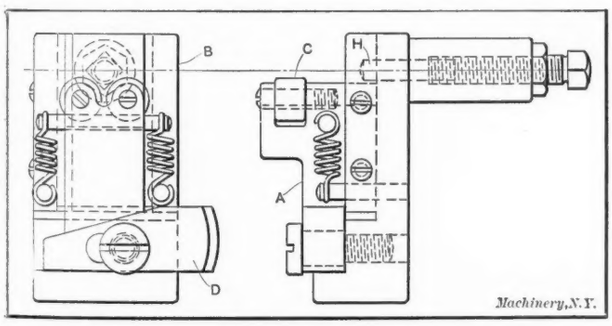


Fig. 8. Combination Stop and Support used in Arrangement for Supporting Long Work shown in Fig. 6

which in turn is operated by the cam attachment E. To fasten the cam attachment to the machine, as shown in Fig. 6, the stop which is used for locating the slotting arm when it is in position to travel onto the work, is removed, and the cam attachment is screwed down in its place. Two dowel pins a have been added to the cam attachment to hold it rigid.

A detailed sketch of the cam attachment is shown in Fig. 7, from which the operating parts can be clearly understood; the combination stop and support is shown in Fig. 8. The operations to produce the piece F, Fig. 6, would be as follows: The part b is left to project out of the chuck far enough so as to allow it to be threaded. To start the operations, the part b is formed and threaded; then, after the die leaves the work, the turret is revolved, the support is brought into position and the stock is fed out and gaged to length by the stop H. The spindle is left running backwards and the tool G_1 forms the part c. After the form tool G_1 has finished its work, a knurl-holder, not shown in the illustration, travels over the work and knurls the ends. The cut-off tool G severs the finished piece from the bar, at the same time forming the part b of the next piece. The support can be withdrawn after knurling, or left in position till the piece is cut off, when the turret is revolved and the piece drops out.

Arrangement of Circular Tools

When applying circular tools to the Brown & Sharpe automatic screw machines, the arrangement of the tools has an important bearing on the results obtained. The various ways of arranging the circular tools, with relation to the rotation of the spindle, are shown at A, B, C, and D, Fig. 9. These are to be considered as being viewed looking from the turret towards the face of the chuck. The arrangement at A gives good results when long forming is to be performed on brass, steel or gun-screw iron, for the reason that the pressure of the cut is downward and hence the work is supported and held more rigidly than when the form tool is turned upside down on the front slide as shown at B; here the stock turning up towards the tool has a tendency to lift the cross-slide, causing chattering on the finished body of the work; therefore, the arrangement as shown at A is recommended when a high finish is desired. The arrangement at B works satisfactorily when forming short steel pieces which do not require a high finish, as it allows the cuttings to drop clear of the work, and also provides for a good supply of oil to reach the tools. This arrangement gives good results when making screws when the form and cut-off tools operate after the die, as no time is lost in reversing the spindle. The arrangement

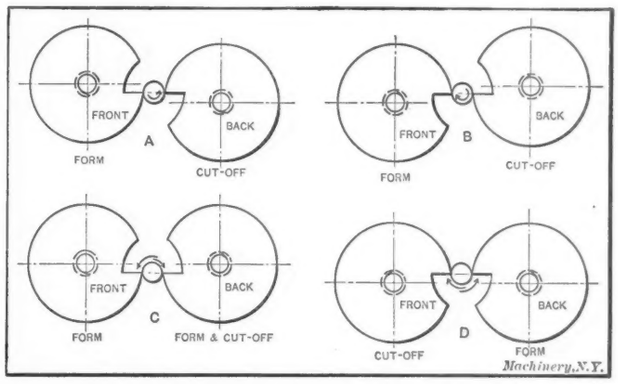


Fig. 9. Different Arrangements of Circular Tools

at C is recommended for heavy cutting on large work, when both tools are used for forming the piece; a rigid support is then necessary for both tools and a good supply of oil is also required. The arrangement at D is objectionable, and should be avoided, being used only when a left-hand thread is cut on the piece, and when the cut-off tool is used on the front slide, leaving the heavy cutting to be performed from the rear slide. In all "cross-forming" work, it is essential that the spindle should be kept in good condition, and the collet or chuck have a parallel contact upon the bar which is being formed.

Forming Spherical Work

In the making of spherical head screws or other spherical work, the circular form tool is generally used for forming part of the head, leaving the part attached to the bar to be finished by the cut-off tool. This method has become general practice on the Brown & Sharpe automatic screw machines and has proved, without a doubt, to be the most economical and efficient method of performing operations of this description. In order to produce the best results by the above method, the radius of the cut-off tool should be struck off in advance of the edge of the tool, as will be described later; otherwise a result will be produced as shown at a, Fig. 12, a ridge being formed on the head. The circular form tool should be de-

signed first, and should be made so that the circular cut-off tool will have as little as possible to form when cutting the piece from the bar. The amount that the form tool reduces the bar, as shown at *b*, Fig. 12, is governed by the operations following the forming cut. If heavy cuts are taken, the part *b* should be strong enough to resist the twisting action produced; therefore, it is not always advisable to cut a thread (especially if it be of coarse pitch) after the piece has been considerably reduced by the form tool.

In designing the form tool, there are certain dimensions which must be derived by calculation. Referring to **Fig. 10.**

Let r = radius of stock = $\frac{D}{2}$,

R = radius of head of screw or piece,
D_1 = distance from axis of head to point of tool.
D = diameter of head of piece,
T = thickness of head,
r_1 = radius of body of screw or piece,
O = the dimension required to be found by calculation.

Then $O = \sqrt{R^2 - D_1^2} - (R - T)$.

For example, let $r = 0.175$ inch, $R = 0.178$ inch, $D_1 = 0.062$ inch, $T = 0.156$ inch.

Then $O = \sqrt{0.178^2 - 0.062^2} - (0.178 - 0.156) = 0.145$ inch.

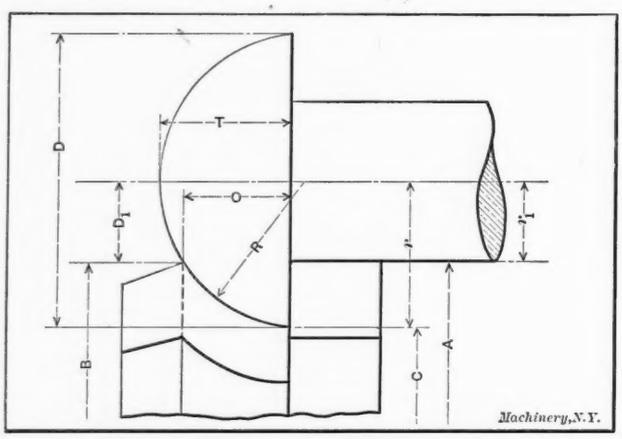


Fig. 10. Diagram for Calculating Dimensions of Circular Tools forming Spherical Screw Heads

Assume further that a form tool is to be made to form a piece as shown at Fig. 10; $r = 0.175$ inch; $r_1 = 0.043$ inch; then assume the largest diameter A to be 1.750 inch, the diameter B will be:

$A - 2\ (D_1 - r_1) = 1.750 - 2\ (0.062 - 0.043) = 1.172$ inch,

and the diameter C will be:

$A - 2(r - r_1) = 1.750 - 2(0.175 - 0.043) = 1.486$ inch.

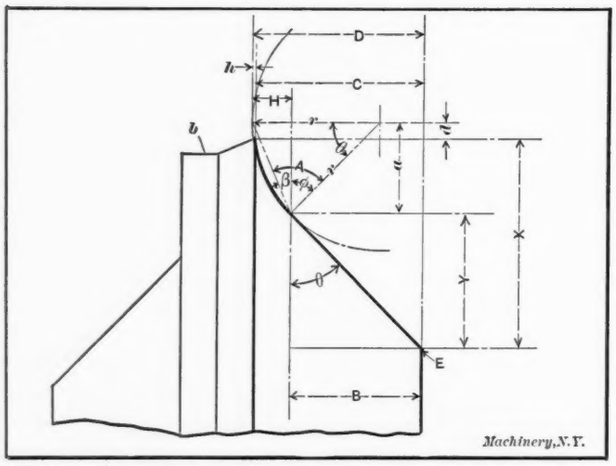


Fig. 11. Diagram for Determining Dimensions of Circular Cut-off Tool which forms Part of a Spherical Screw Head

In the above calculations the "cut-down" below the horizontal center line is not taken into consideration when finding the various diameters, but if the forms produced require to be accurate, the differences should be calculated. This question will be treated in a future issue of MACHINERY.

The feed of the circular cut-off tool should be decreased at the end of the cut, so as to leave as small a teat as possible on the work. The teat varies according to the radius formed, the size of the piece and the nature of the material. It is, therefore, impossible to specify any exact size of teat for a certain piece, but the results of a few experiments would not be out

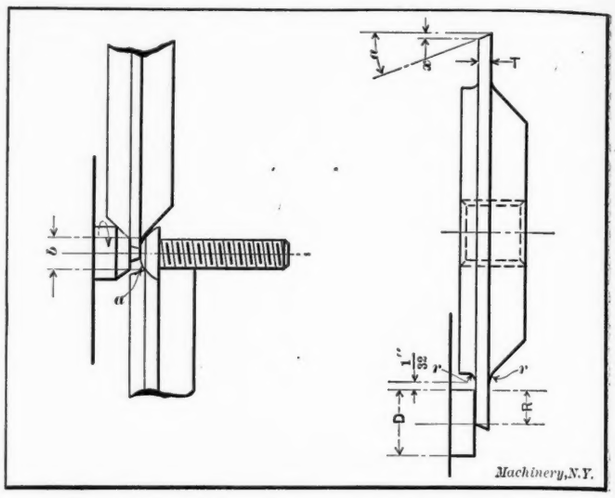


Fig. 12. Spherical Screw Head formed by Combination of Forming and Cut-off Tools

Fig. 13. Diagram showing Dimensions of Circular Cut-off Tools

of place here, as they will give a fair idea of the sizes of teats left on various classes of work. The teat left on small brass screws varies from 0.010 inch to 0.025 inch in diameter; on small screws made from gun-screw iron from 0.012 inch to 0.030 inch; on small steel screws from 0.015 inch to 0.035 inch. A good method of overcoming great variation in the size of the teat, is to make the angle of the cut-off tool similar to the enlarged view shown at *b*, Fig. 11, where the flat portion should be half the thickness of the cut-off tool blade. This method tends to decrease the pressure on the piece, thus preventing it from breaking off too soon.

As previously stated, the radius on the cut-off tool, if not struck off in "advance" of the edge of the tool, will give a result as shown at *a*, Fig. 12. There will always be a mark left on the head where the form tool finishes cutting, because the screw breaks off from the bar before the point of the tool has reached the center, and consequently the radius on the piece has not been completed. It is therefore necessary (especially for small radii) to lay off the radius in advance of the cutting edge of the tool. This method is clearly shown in Fig. 11, where d is the distance the center is in advance of the point of the tool. Then, to determine the dimensions of the tool, take any approximate dimension D as required, and also take any angle which will suit the radius of the tool, and cut away that portion of the tool which is not required for forming. In order to determine the dimension X (see Fig. 11) it will be necessary to make the following calculations:

$$A = \frac{180 \text{ deg.} - \theta}{2}$$

$$\phi = 90 \text{ deg.} - \theta$$

$$\beta = A - \phi$$

Then $a = \cos \phi \times r$; $H = \tan \beta \times a$; $B = D - H$;

$Y = B \times \cot \theta$; $X = Y + a - d$; $C = D - h$;

$h = r - \sqrt{r^2 - d^2}$.

Where h works out to less than 0.002 inch, it can be disregarded for all practical purposes.

For example, let $D = 0.2343$ inch; $r = 0.175$ inch; $\theta = 45$ deg.; $d = 0.021$ inch;

Then $A = \frac{180° - 45°}{2} = 67°\ 30'$.

$\phi = 90° - \theta = 45°$.
$\beta = 67°\ 30' - 45° = 22°\ 30'$.
$a = \cos\ 45° \times 0.175 = 0.1237$.
$H = \tan\ 22°\ 30' \times a = 0.0512$.
$B = 0.2343 - 0.0512 = 0.1831$.

$Y = 0.1831 \times \cot 45° = 0.1831.$

$X = 0.1831 + 0.1237 - 0.021 = 0.2858.$

$h = r - \sqrt{r^2 - d^2} = 0.175 - 0.1737 = 0.0013.$

Therefore, in this case for all practical purposes, the dimension C would equal the dimension D. When the largest diameter of the circular tool is 2.250 inch, the diameter of the tool at point E will be $2.250 - (0.2858 \times 2) = 1.6784$ inch.

Angle on Blade for Cutting Off Various Materials

The function which the angle on the edge of the tool performs is to reduce the teat on the end of the work by minimizing the cutting pressure which becomes greater as the angle that the tool makes with the work decreases. Therefore, as the material becomes harder, the angle on the tool may decrease, since the material will stand more pressure before breaking. It is obvious, therefore, that certain angles are better suited for the various kinds of material than others. The values given in Table I have been found to give good results on the materials specified.

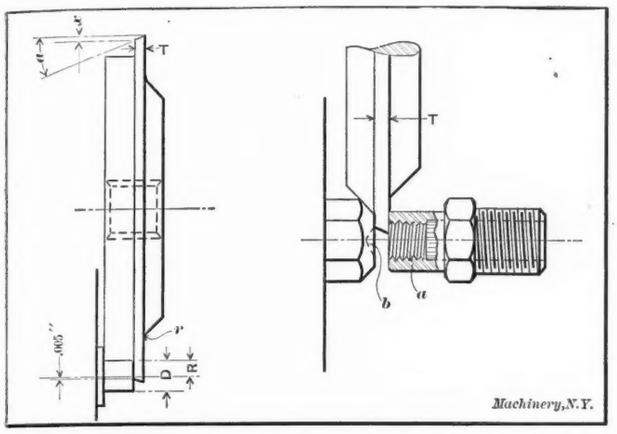


Fig. 14. Diagram showing Dimensions of Circular Cut-off Tool when it is used both for cutting off and forming part of the Work

Fig. 15. Illustration showing a Case where a Cut-off Tool with Increased Thickness of Blade is required

Thickness of Blade on Cut-off Tools

The thickness of the blade is an important point in the design of circular cut-off tools. It is governed by the angle on the edge of the tool and also the diameter and hardness of the material being operated on. It is obvious that a circular tool with an acute angle (about 23 degrees) and a narrow blade would not work satisfactorily on hard material, as the blade would not stand the cutting pressure and would bend, producing a concave surface on one end of the piece and a convex surface on the other. This has been thoroughly experimented with by the writer and an empirical formula has been derived which has given good results. For standard circular cut-off tools, as shown in Fig. 13, where the tool is not required to form part of the work, the formula is as follows:

$$T = \sqrt{\frac{D \times \cot a}{3}} \times 0.14,$$

where T = thickness of blade in inches,
D = the diameter of the stock in inches,
a = the angle on the edge of cut-off blade.

The value of r (the radius to obviate cracking in hardening) for standard circular cut-off tools for cutting off various diameters of stock is as follows:

From 1/8 to 3/8 inch diameter = 1/32 inch,
From 3/8 to 3/4 inch diameter = 1/16 inch,
From 3/4 to 1 inch diameter = 3/32 inch.

The actual length of the blade on cut-off tools is found by the formula:

$$L = R + x + r + 1/32,$$

where L = actual length of blade in inches,
R = radius of stock in inches,
x = dimension as shown in Fig. 13,
r = radius to obviate cracking while hardening, as shown in Fig. 13.

For example let $D = 3/8$ inch; $a = 20$ degrees.

Then $T = \sqrt{\frac{D \times \cot a}{3}} \times 0.14 = \sqrt{\frac{0.375 \times 2.747}{3}} \times 0.14 =$ 0.082 inch.

$L = R + x + r + 1/32$, where $R = 0.1875$; $x = \tan 20° \times 0.082 = 0.364 \times 0.082 = 0.0298$; $r = 1/32$ inch.

Therefore, $L = 0.1875 + 0.0298 + 0.0312 + 0.0312 = 0.2797$ inch.

The thickness of the cut-off tool blade, and the value of x and $2x$ are tabulated in Table I. The above formula is applicable where the cut-off tool does not form down the stock. It will be necessary to change the formula somewhat when calculating the thickness of blade when the tool is used for partly forming the work, as shown in Fig. 14.

TABLE I. DIMENSIONS FOR CIRCULAR CUT-OFF TOOLS (For Notation See Fig. 13)

Diameter of Stock	Soft Brass and Copper			Hard Brass			Gun Screw Iron			Norway Iron and Mach. Steel			Drill Rod and Tool Steel		
	Angle a = 23 Deg.			Angle a = 20 Deg.			Angle a = 16 Deg.			Angle a = 15 Deg.			Angle a = 10 Deg.		
	T	x	2x	T	x	2x	T	x	2x	T	x	2x	T	x	2x
1/16	0.031	0.013	0.026	0.033	0.012	0.024	0.035	0.011	0.023	0.039	0.010	0.021	0.043	0.009	0.018
1/8	0.044	0.019	0.038	0.047	0.017	0.034	0.050	0.016	0.032	0.055	0.015	0.030	0.062	0.013	0.026
3/16	0.052	0.022	0.044	0.058	0.021	0.042	0.061	0.020	0.040	0.068	0.018	0.036	0.076	0.016	0.032
1/4	0.062	0.026	0.053	0.067	0.024	0.049	0.071	0.023	0.046	0.078	0.021	0.042	0.088	0.019	0.038
5/16	0.069	0.029	0.059	0.075	0.027	0.055	0.079	0.026	0.052	0.087	0.023	0.047	0.098	0.021	0.042
3/8	0.076	0.032	0.065	0.082	0.030	0.060	0.087	0.028	0.057	0.095	0.025	0.051	0.107	0.023	0.046
7/16	0.082	0.035	0.070	0.088	0.032	0.064	0.094	0.031	0.062	0.103	0.028	0.056	0.116	0.025	0.050
1/2	0.088	0.037	0.075	0.095	0.035	0.070	0.100	0.033	0.066	0.110	0.029	0.059	0.124	0.026	0.052
9/16	0.093	0.039	0.079	0.100	0.036	0.073	0.106	0.034	0.069	0.117	0.031	0.063	0.131	0.028	0.056
5/8	0.098	0.042	0.084	0.105	0.038	0.076	0.112	0.036	0.073	0.123	0.033	0.066	0.137	0.029	0.058
11/16	0.103	0.044	0.088	0.111	0.040	0.081	0.118	0.038	0.077	0.129	0.035	0.070	0.145	0.031	0.062
3/4	0.107	0.045	0.091	0.116	0.042	0.084	0.123	0.040	0.080	0.134	0.036	0.072	0.152	0.032	0.064
13/16	0.112	0.047	0.095	0.121	0.044	0.088	0.127	0.041	0.082	0.141	0.038	0.076	0.158	0.033	0.067
7/8	0.116	0.049	0.098	0.125	0.046	0.092	0.133	0.043	0.086	0.146	0.039	0.078	0.164	0.035	0.070
15/16	0.120	0.051	0.102	0.130	0.047	0.095	0.137	0.045	0.090	0.151	0.040	0.081	0.170	0.036	0.072
1	0.124	0.053	0.106	0.135	0.049	0.098	0.141	0.046	0.092	0.156	0.042	0.084	0.175	0.037	0.074

When Cut-off Tool Forms Stock

When the cut-off tool is used to form down end of stock, as shown at Fig. 14, the following formula is used for finding the thickness of blade:

$$T = \sqrt{\frac{D \times \cot a}{5}} \times 0.17,$$

where T = thickness of blade on cut-off tool in inches,
D = diameter of end of piece in inches,
a = angle on edge of tool blade (see Fig. 14).

The actual length of the cut-off tool blade = $R + x + 0.005$ inch,

Where R = radius on end of piece in inches,
x = dimension as shown in Fig. 14.

The dimension 0.005 inch is the clearance to pass the center. To find the value of x multiply T by tan a as before.

For example, let $D = 0.250$ inch, $a = 20$ degrees.

Then $T = \sqrt{\frac{0.250'' \times \cot 20}{5}} \times 0.17 = \sqrt{0.13737} \times 0.17 = 0.063$

$L = R + x + 0.005$, where $R = 0.125$ inch; $x = 0.063 \times \tan 20° = 0.023$ inch.

Then $L = 0.125 + 0.023 + 0.005 = 0.153$ inch.

In cases where pieces are being manufactured similar to that shown in Fig. 15, where the tapped hole *a* is not bottomed but passes through the piece (it being necessary to have a chamfer on the tap to facilitate tapping), the blade on the cut-off tool would have to be of sufficient width to remove the portion taken up by the chamfer on the tap. Otherwise, if the blade is too narrow, the hole *b* will extend part way into the next piece to be made. Then, if the drill had a tendency to run eccentric, the centering tool would not remove the eccentric hole thus formed by the drill, which would result in the drill running out and finally in the breaking of the tap before many pieces would be completed.

The amount of chamfer required on taps for various pitches is as follows:

	Lead
From 14 to 24 threads.....	2½ threads.
From 26 to 32 threads.....	3 threads.
From 36 to 48 threads.....	4 threads.
From 56 to 80 threads.....	5 threads.

When the thickness of the blade as derived by the formulas is not equal to the amount required for the lead on the tap, the thickness of the blade must be increased to at least the amount specified as lead on tap.

* * *

COST OF POWER FOR VARIOUS INDUSTRIES

In a paper entitled "Cost of Power for Various Industries Under Ordinary Conditions," which was presented before the Boston Society of Civil Engineers, by Messrs. Charles T. Main and F. M. Gunby, the following general summary of the cost of electrical power for various purposes and under varying conditions, was given. The prices quoted are approximately those found in the vicinity of Boston.

Power in small amounts and with a varying demand, can be purchased for from about 10 cents per kilowatt hour, in five kilowatt lots, down to about 6 cents a kilowatt for 100 kilowatt lots, where the power is used for about 50 hours a month.

The rate for a permanent or steady power of 100 kilowatts for 300 hours a month would be about $2.68 per kilowatt hour, and for 500 hours a month about $1.84 per kilowatt hour. The two conditions mentioned are only used as illustrations to show normal cases as in a city like Boston.

Assuming a plant of 2,000 kilowatts capacity, the approximate costs and prices for power are given in the following table:

Kind of Plant and General Use	Hours per Year	Cost per Year			Cost per K.W. Hour
		K. W.	E. H. P.	I. H. P.	
Textile (engine)....	3,000	$32.00	$23.80	$20.80	1.065c.
Textile (turbine)...	3,000	29.00	21.60		0.965c.
Paper mill (engine).	7,200	57.00	42.50	37.00	0.792c.
Paper mill (turbine)	7,200	52.00	38.80		0.734c.

The above figures are for cases where no waste products are used for manufacturing.

For electric lighting or railway work with a load factor of 30 per cent the cost would be about $1.55 per kilowatt hour, or $40 per kilowatt year. This is $29.80 per engine horsepower year or an equivalent of $26.00 per indicated horsepower year.

For paper mill work, 24 hours a day, 6 days a week, power only, $57.00 per kilowatt year, or 0.792 cents per kilowatt hour for engine plant, or about 8 per cent less for a turbine plant. If the waste products were used for manufacturing, these costs might be reduced by about one-third.

For industrial plants, 10 hours a day, 300 days a year, straight power would cost $32.00 per kilowatt year. If heating is done, by exhaust steam, these figures may be reduced by about $1.20 per kilowatt or to say, $30.60 per kilowatt year. This would be about $23.00 per engine horsepower and $20.00 per indicated horsepower year.

For colored textile mills, making use of exhaust steam and water of condensation, the original cost of straight power would be the same as that given in the preceding paragraph. This may be reduced by using the exhaust steam and waste products by from $2.00 to $12.00 per kilowatt year, depending upon the amount of steam and waste products used.

The common price for hydro-electric power, 24 hours a day, 6 days a week, is from $30.00 to $40.00 per electrical horsepower or $40.00 to $53.50 per kilowatt.

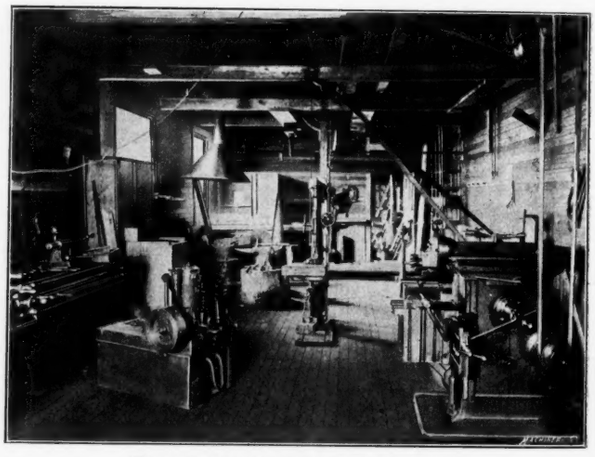
The common price for hydro-electric power, 10 hours a day, 3,000 hours a year, is from $20.00 to $25 per electrical horsepower, or from $27.00 to $33.50 per kilowatt.

* * *

A MACHINE SHOP IN ALASKA

By C. S. BROWN*

The readers of MACHINERY may be somewhat interested in a thriving little machine shop in the far north near Valdez, Alaska. The proprietor is Mr. Charles Crawford, who is considered one of the best all-around machinists on the Pacific coast, having left behind in Seattle a reputation for mechanical skill of which any man might well be proud. The various shops cover about three acres of ground and employ a dozen men most all the time. The machine shop is equipped with milling machines, lathes, drills, etc., and stands ready to build anything from a stove to a ship. For example, it has built two wharves, and an 80-foot launch which was sold to the United States government for $21,000. While doing a general machine business, its principal work is the manufacturing and installation of mining machinery such as hoisting machinery, pumps, drills, etc. One of its most important branches of work is the building and repairing of motor boats,



View of a Machine Shop at Valdez, Alaska

of which there are a few hundred in Valdez Bay. Beside wharf building, the manufacture of freight sleds is work that tends to make up a lucrative business. In connection with the machine business there is a tin shop which is always kept busy. Notwithstanding the fair wages paid to machinists—62½ cents per hour—Mr. Crawford experiences considerable difficulty in obtaining men, as most machinists, like the majority of workmen in Alaska, feel strongly the call of the north and go into the hills to seek the illusive pot of gold that is so well secreted in the frozen earth. A few are successful, but the most return with empty pockets. One machinist who has been smiled upon by Dame Fortune is Jack Carroll, who was one of Dr. Cook's guides on the Mt. McKinley trip.

Valdez is situated near the head of a beautiful land-locked bay on Prince William sound in the Gulf of Alaska. It is open to navigation the year round, and has water deep enough to float the world's navies. Six Seattle steamers call monthly with mail and merchandise, and the trip between the two ports is often made in four days. It takes nine days for a letter to reach Boston from there. Valdez is the farthest north open-all-the-year port in America.

* Address: 206 Clark Place, Elizabethport, N. J.

HANDLING AND STORING COMMERCIAL IRON AND STEEL PRODUCTS

By ETHAN VIALL*

There is a vast difference between the handling and storing of pig iron and that of the product that comes from the mills. The former may be loaded into cars with magnets—or just dumped in—and it may be unloaded on the same plan; but for handling sheets of metal, bars, tubes or beams, dumping is out of the question and magnets are impracticable and dangerous; that being the verdict of the firm of Joseph T. Ryerson & Son, Chicago, who probably handle more structural iron, sheet metal, bars and material of that sort than any other firm in the world.

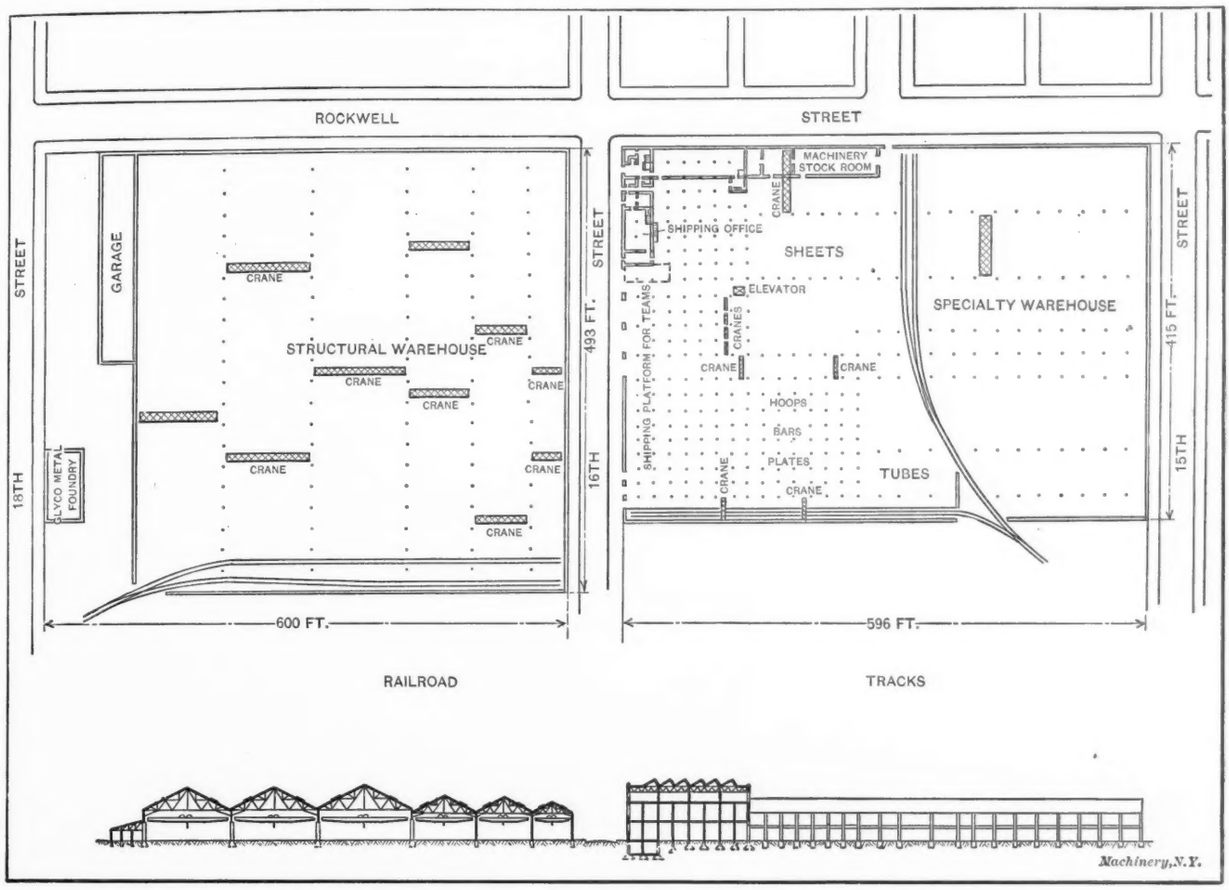


Fig. 1. Ground Plan of the Warehouse of Joseph T. Ryerson & Son, Chicago, Ill.

material. The structural warehouse alone covers over eight acres. It is divided into bays, each being about five hundred feet long and varying in width from forty-five to one hundred and ten feet. All buildings are of steel construction throughout, with roofs of corrugated iron and glass. Three railroad switch tracks enter the structural buildings and extend along the entire east end, furnishing, under roof, accommodations for forty-nine cars at one time. The crane service operating in each bay over and at right angles to the railroad tracks, affords loading and unloading facilities which cannot be excelled. These shipping facilities of the structural warehouse, are supplemented by two wide wagon driveways, one entering the northeast portion of the plant and the other the southwest. These driveways are wide enough for a number of wagons, and like the switch tracks, are accessible to the entire warehouse crane service. The crane equipment is exceptionally extensive and complete, being composed of eight high-speed traveling bridge-cranes and two radial wall jib-cranes in addition to the roller-tables and hoist systems used in connection with the various machines. Of the cranes just men-

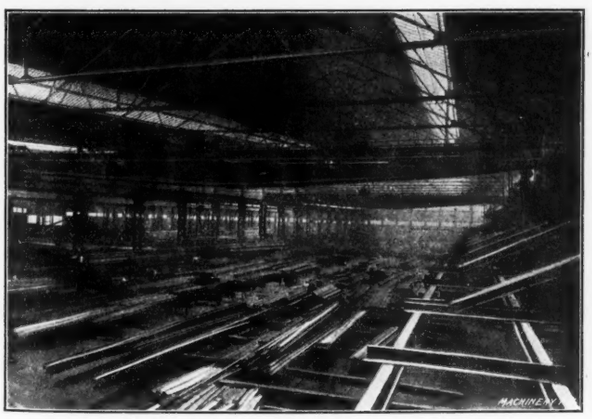


Fig. 2. View in the Structural Warehouse showing Cranes and Method of Storing Stock

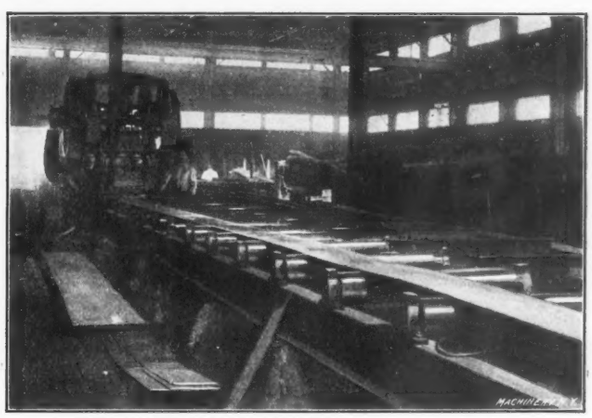


Fig. 3. Roller Table used to feed Stock to Big Shears

The general layout of the great Ryerson system of warehouses, the floor plan of which is shown in Fig. 1, is the best for the purpose that modern engineering skill could plan. These warehouses have 750,000 square feet of floor space, affording storage and handling facilities for 150,000 tons of

* Associate Editor of MACHINERY.

tioned, four are of one hundred foot span and ten tons capacity and each is equipped with two trolleys and is operated from a stationary cage. These big cranes have a bridge traveling speed of 350 feet, and a trolley travel of 175 feet per minute.

A view of one of the structural warehouse bays and two of the cranes, is shown in Fig. 2. This view also shows the method of laying I-beams, etc., on structural iron "horses" so that they may be more easily picked up.

As just mentioned, the crane system is supplemented by an elaborate and carefully designed motor-driven, roller-table system, parts of which extend in three trains across the entire building and feed the high-speed friction saws and heavy shearing machinery. Fig. 3 shows one of these roller-tables that is used to carry material to one of the big shears, and in Fig. 4 is shown the roller-table of one of the big friction disk saws. The adjustable stop by which the length of the piece to be cut is gaged is shown at *A* and at the left of the rolls, may be seen the shaft and bevel gears by which the rolls are driven. Fig. 5 is a closer view of the saw from the other side, and shows the operator's seat and controlling levers in the foreground. Fig. 8 shows a view of another table with the saw in the act of tearing through an I-beam. These friction disk saws have been previously described in detail in several technical journals, so only a very brief description will be given here. Each machine consists of a steel sliding

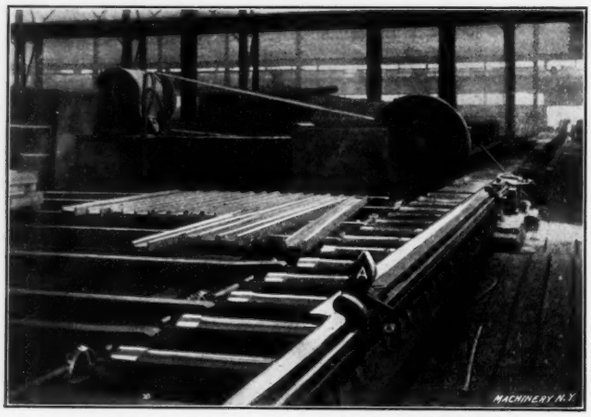


Fig. 4. Roller Table for the Friction Disk-saw

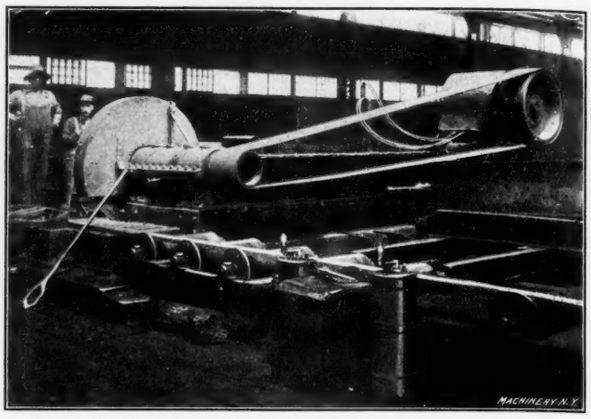


Fig. 5. Another View of the Friction Disk-saw showing Controller

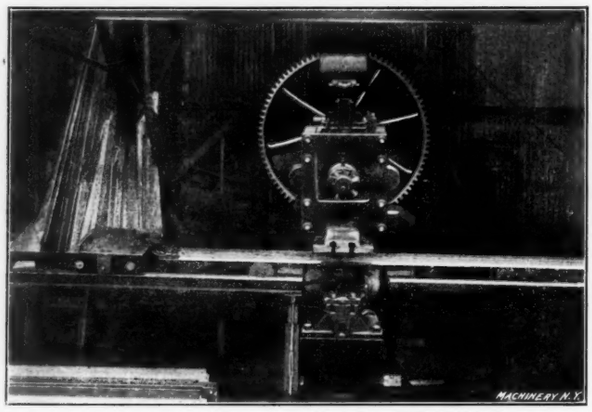


Fig. 6. Punch Press and Device used to space Holes in Angle Irons

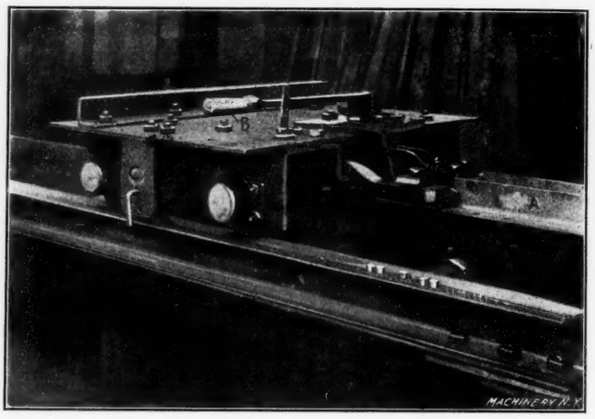


Fig. 7. Detailed View of the Punch-press Spacing Mechanism

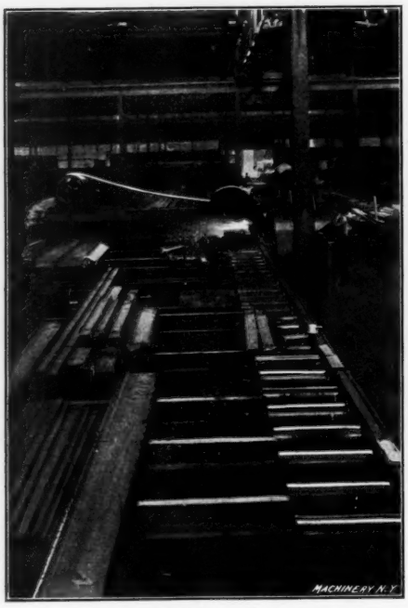


Fig. 8. One of the Friction Disk-saws cutting a 10-inch I-Beam

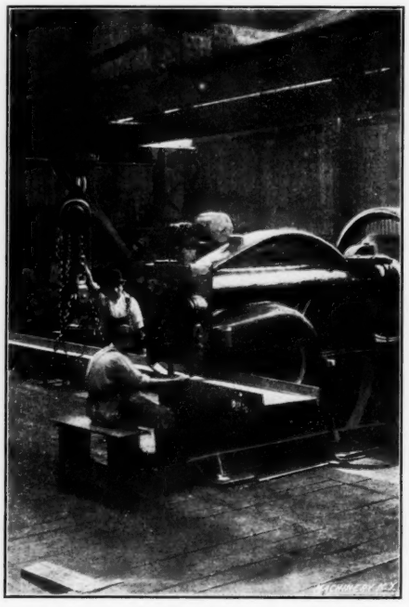


Fig. 9. Traveling Hoist used to feed I-Beam under the Punch

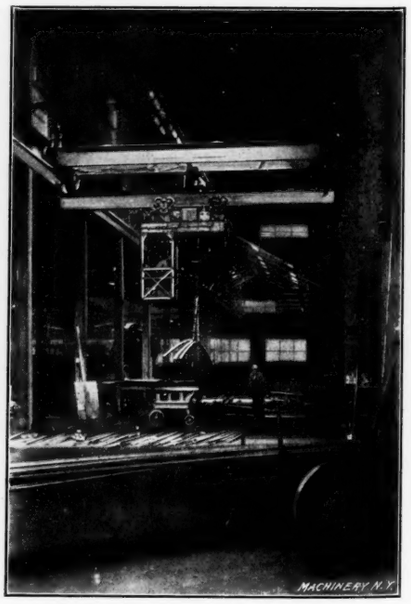


Fig. 10. Cranes carrying Strap Iron to the Scales

carriage, hydraulically driven forward and backward in V-grooves, on a structural steel and cement foundation or bed. The saws are 52 inches in diameter, made of ⅜ inch flanged steel, and run, driven by a 100-H. P. motor through a three-ply 16-inch belt, at a peripheral speed of 27,000 feet a minute.

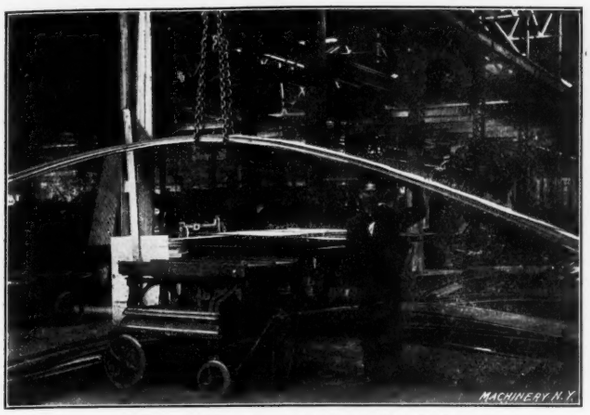


Fig. 11. Closer View of the Portable Scales

There are no teeth on the saw, but the edge is hacked closely by using a fishtail chisel and a hammer, and instead of cutting, the disk literally melts its way through. The entire machine is 22 feet long, 5 feet 6 inches wide, and weighs about 35,000 pounds. Some idea of the cutting capacity of these machines can be had from the fact that a 24-inch, 100-pound I-beam is cut in less than twenty seconds.

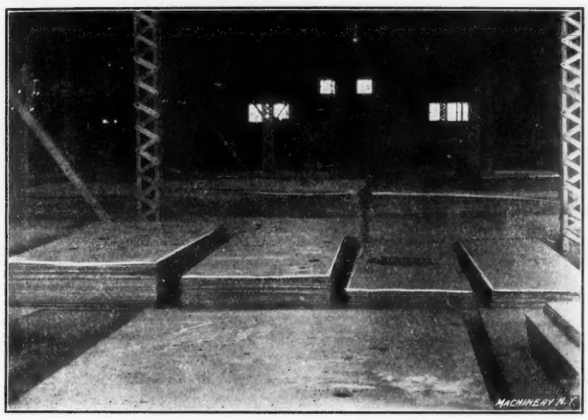


Fig. 13. The Way Flat Plates are stored

In Fig. 6 is shown a very unusual spacing device that is attached to a punch press. It is designed to feed two angle irons (right and left) at once under the punches, so that the holes wanted may be punched quickly and accurately, and any number of pairs may be spaced and punched exactly alike. The device itself is shown on a larger scale in Fig. 7. It consists of a carriage mounted on wheels which run on a channel-iron track, one rail of which is drilled with three rows of holes so spaced that a stop-pin may be set every eighth of an inch; by filing a pin half away, a stop can be made within 1/16 inch of any distance, or number of distances, wanted within the length of the rail, which has been made ample for all needs. The angle irons *A* are clamped by means of the lever *B*. A dog back of the piece *C*, does the spacing for the carriage, as it drops over and is held against each pin in turn. The dog may also be lifted out of the way of the stop-pins, by using the handle just under the letter *C*, when it is desired to run the carriage out or in for any purpose.

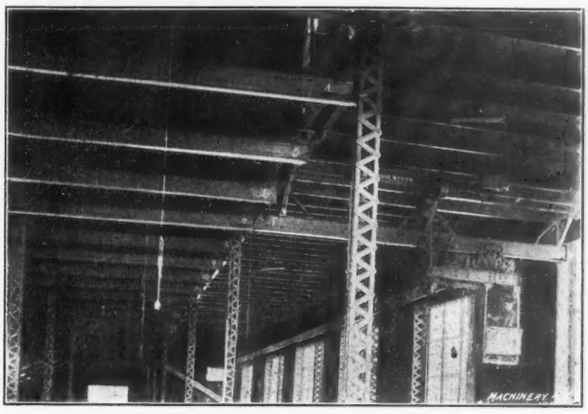


Fig. 12. System of I-Beams for Crane Trolley

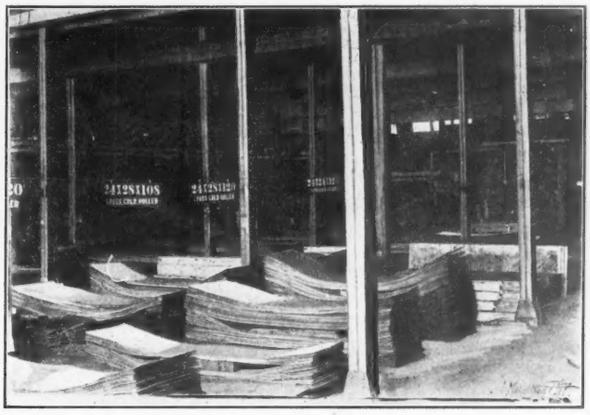


Fig. 14. The Way Bundles of Sheet Metal are stored

In Fig. 9 is shown a small traveling hoist that is used to handle I-beams while punching rivet holes in them.

Fig. 10 shows a crane in the plate and bar warehouse, carrying band iron to one of the portable scales. A closer view of the scale is given in Fig. 11. These scales are easily taken anywhere that is most convenient.

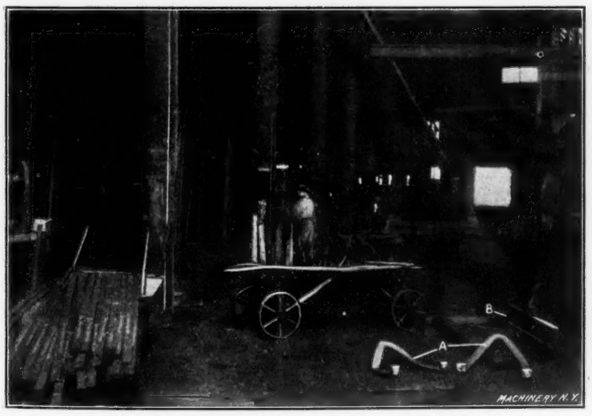


Fig. 15. Grappling Claws for Plates, and Push Truck

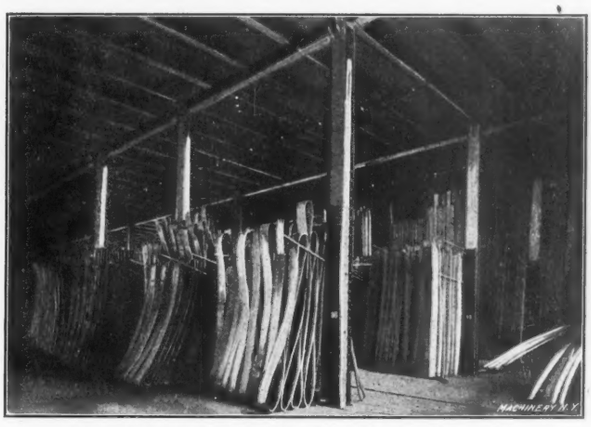


Fig. 16. The Way Strap, Band or Hoop Iron is stored

The crane system of the plate and bar warehouse, just referred to, is unusual. This building is of heavy steel, two-story construction and provides 140,000 square feet of storage space. It has double crane runways, which extend the entire length of the structure, one on each side. The cranes are of ten tons capacity, and are so designed that the carriages can

be run off of the crane bridges proper onto the I-beam trolley system, illustrated in Fig. 12, which serves the entire storage floors. Beneath one of the crane runways, there is a switch track, and beneath the other, a wagon driveway, both of which extend the entire length of the building, so it will be seen that any material, such as the plates shown in Fig. 13, for example, may be taken off of a car or wagon and carried by the crane directly to and deposited on the pile designated, with but one handling. As the illustration just referred to indicates, all plate stock is laid on the floor in flat piles for convenience and to prevent distortion, each size being located in a separate pile and arranged in bays according to grade and thickness. The light sheet iron in bundles, is also stored in this way as shown in Fig. 14.

At the beginning of this article, it was stated that magnets are not used at all here as they are unsatisfactory and too dangerous for this kind of work. All crane grappling is done by means of chains or single beam-hooks or claws, two claws for plates being shown at *A*, Fig. 15, while at *B* is a short

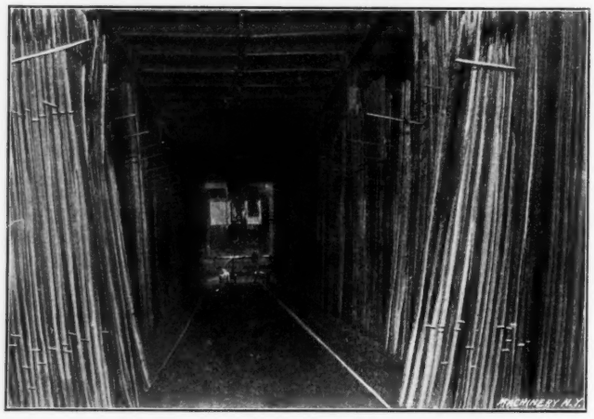


Fig. 17. A View in the Bar Stock Storage

I-beam with an eye in the middle for the crane-hook and chains at each end, which is used for handling limber band iron, wide plates and other stock.

A rather surprising thing to most people when visiting these warehouses for the first time, is that all band and bar stock, of which there are 740 sizes carried, is stood up on end as shown in Figs. 16 and 17.

Located on the main floor of the north warehouse, and between the plate and sheet storage sections, are three heavy motor-driven, guillotine plate-shears, the largest one of which has the power and capacity to shear 12 feet of 2-inch steel plate at one stroke, and it weighs 260,000 pounds and stands 28 feet above the floor.

Boiler flues are brought in on cars as shown in Fig. 18,

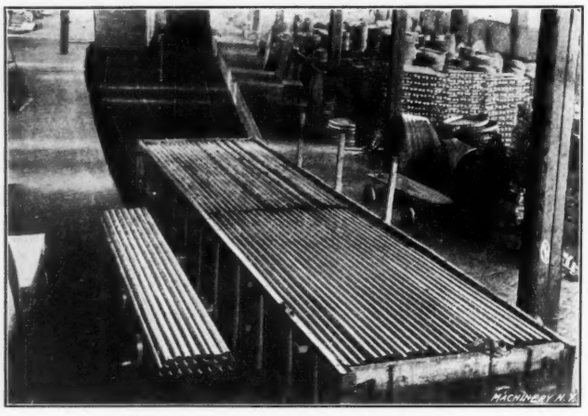


Fig. 18. Boiler Tubes loaded for Shipment

loaded onto small push trucks and then stored in structural steel racks as in Fig. 19. The various qualities of tubes such as seamless steel, lap weld steel, charcoal iron, etc., are each given different sections of the floor, while each size and length is given a separate compartment.

It must not be imagined by those not familiar with this firm, that the brief description here given covers even a small part of the immense variety of material handled and stored by the concern, for the variety of the structural and special steel and iron material, machines and specialties, is almost endless and only enough has been mentioned to give something of an

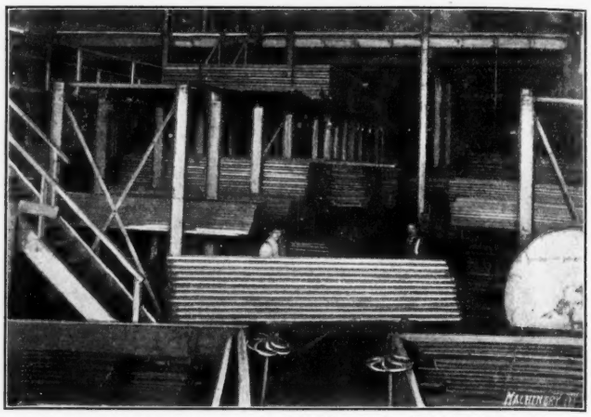


Fig. 19. Structural Iron Racks in which Boiler Tubes are stored

idea, in a general way, as to the methods used in the handling and storing of this material, in the greatest iron and steel "department store" in the world.

* * *

THE STRENGTH OF CHANNELS AND OTHER STRUCTURAL SHAPES

Experiments on standard channels carried out by Mr. C. Bach and reported in detail in the *Zeitschrift des Vereines deutscher Ingenieure*, issue of October 30, 1909, show that the regular bending formula for beams freely supported at their ends and loaded in the center gives too high a value for the strength of structural channels. The experiments show that the amount by which the value obtained from the formula is greater than that obtained by experiments, is, for channels

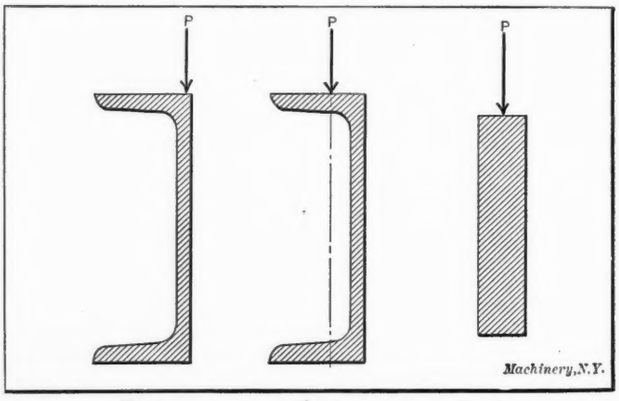


Fig. 1 Fig. 2 Fig. 3

twelve centimeters (4¾ inches) high, 7 per cent; for channels 22 centimeters (8¾ inches) high, 18 per cent; and for channels 30 centimeters (11¾ inches) high, 26 per cent. These values are those found when the load is assumed to be applied in the center line of the web of the channel as shown in Fig. 1. If the load is placed along the line of the vertical neutral axis of the channel as shown in Fig. 2, the permissible load according to the beam formula is 10, 25.5 and 34 per cent greater than that shown by the experiments. These experiments, therefore, indicate that when the usual formulas are employed in calculations, for channels or other structural shapes, a liberal factor of safety should be allowed in order to compensate for the difference of the results given by the formula and those of actual experiments. It should be noted, that apparently the formula for bending is fully correct whenever the section of the member is such that the load is fully distributed over the whole sectional area, as in a rectangular section, Fig. 3; but in the case of channels as well as many other structural shapes, the load is not, as a rule, properly distributed over the whole section, but stresses certain portions of the section in a higher degree than others.

MAKING A PRECISION DIVIDING WHEEL

There are various methods employed for making accurate indexing wheels for a definite number of divisions. One of these methods, suitable particularly for small numbers of divisions, employs a split wheel with a series of taper holes reamed through the two divisions. By shifting the two divisions from point to point and reaming and re-reaming the taper holes at each shifting, they may finally be brought very accurately into position. Another method that has been employed consists in clamping about the rim of the dividing wheel a number of precisely similar blocks, fitting close to each other and to the wheel itself. These blocks are then used for locating the wheel in each of its several positions in actual work. A third and simpler method (a modification of the one last described) consists in grinding a series of

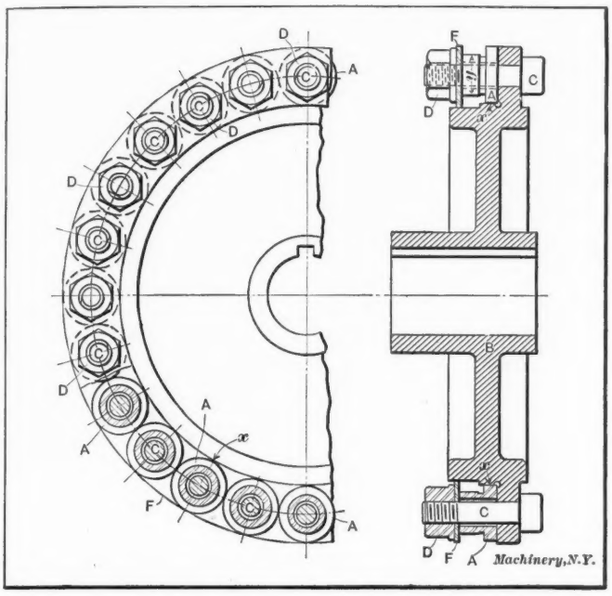


Fig. 1. An Improved Construction for Dividing Wheels of the Disk Type

disks and clamping them around a rim of such diameter that the disks all touch each other and the rim simultaneously. The wheel we are to describe is made in this way. It is shown in Fig. 1.

In this, wheel disks *A* are clamped against an accurately ground face of the wheel *B* and are supposed to just touch each other all around, and to be each of them in contact with the ground cylindrical surface at *x*. They are held in proper position by bolts *C* and nuts *D*. The bolt fits loosely in the hole of the disk or bushing *A* so that the latter is free to be located as may be desired with reference to the bolt.

One or two improvements in the construction of this type of dividing wheel may be noted before proceeding to a description of the way in which it is made. For one thing, instead of having an indexing bolt enter the V-space between two adjoining disks, a smaller diameter *y* is ground on each of them, over which locking finger *E* (see Fig. 2) passes, holding the wheel firmly from movement in either direction. This construction has the advantage of a probable lessening of error by locating on each bushing instead of between two bushings; it gives a better holding surface and better holding angles, as well, than would be the case if this smaller diameter were not provided.

A second improvement refers to the method of clamping the bushing *A* in place. Instead of providing each bolt with a separate washer, a ring *F* is used. This ring fits closely on a seat turned to receive it on the dividing wheel *B*. When one bushing *A* has been clamped in place, the disk is locked from movement so that there is no possibility, in clamping the remaining bushings, of having their location disturbed in the slightest degree by the turning of the nuts in fastening them in place.

The bushings *A*, of which there were in this case 24, were first all ground exactly to the required diameters on their locating and locking surfaces. The important things in this operation are, first, that the large or locating diameter of the bushing should be exactly to size; and second, that this surface should be in exact alignment with the diameter in which the locking is done; and, finally, that the face of the bushing should be squared with the cylindrical surfaces. A refined exactness for the diameter of the locking surfaces is not so important, as the form of locking device provided allows slight variations at this point without impairment of accuracy. This dimension was kept within very close limits, however. The truth of the two cylindrical surfaces and the face of the bushing was assured by finishing all these surfaces in one operation on the grinding machine.

The sizing of the outer diameter of the bushing, which was 1.158 inch, must be done so accurately that it was not thought wise to trust to the ordinary micrometer caliper. An indexing device was therefore made with a calipering lever, whose long end, in the ratio of 10 to 1, actuated the plunger of a dial test indicator of the well-known type made by the Waltham Watch Tool Co. The thousandth graduations on the dial of this indicator would then read in ten-thousandths, permitting readings to be taken to one-half or one-quarter of this amount. The final measurements with this device were all taken after dipping the bushings in water of a certain temperature, long enough to give assurance that this temperature was universal in all the parts measured. It will be understood, of course, in this connection, that getting the diameter of these bushings absolutely to 1.158 inch was not so important as getting them all exactly alike, whether slightly over or slightly under this dimension; hence, the precaution taken in measurement.

Wheel *B* was next ground down nearly to size, great care being taken that it should run exactly concentric with the axis on which it is mounted for use. As soon as the diameter of the surface *x* was brought nearly to the required dimension as obtained by calculation, the disks were tried in place. The first one was put in position with its loose hole central on the bolt and clamped in place under ring *F*. The next bushing was then pressed up against it and against the surface *x* of the wheel and clamped in place. The third one was similarly clamped in contact with its neighboring bushing and the wheel, and so on, until the whole circle was completed. It was then, of course, found that the last disk would not fill the remaining space. This required the grinding off of some stock from surface *x*, and a repetition of the fitting of the bushings *A* until they exactly filled the space provided for them.

This operation required, of course, considerably more skill than a simple description of the job would indicate. One of the points that had to be carefully looked out for was the cleaning of all the surfaces in contact. A bit of dust or lint on one of the surfaces would throw the fitting entirely out. The temperature of the parts was another important consideration. As an evidence of the accuracy with which the work was done, it might be mentioned that it was found impossible to do this fitting on a bench on the southern or sunny side of the shop, the variations of temperature between morning and noon, and between bright sunshine and passing clouds, being such that the disks would not fit uniformly. The variation from these minute temperature changes resulted from the different coefficients of expansion of the iron wheel and the steel bushings. The obvious thing to do would be to build a room for this work kept at a constant temperature (preferably that of the body), so that the animal heat of the operator would make no difference in the results. It was found sufficient in this case, however, to do the work on the northern side of the shop where the temperature was more nearly constant, not being affected by variations in sunshine.

The dividing wheel, whose construction has just been described, was made by the Fellows Gear Shaper Co., of Springfield, Vt. It is used for indexing the Fellows gear cutters in the machine in which the teeth are ground. The indexing mechanism of this machine is shown in Fig. 2. The handle *G*, by which it is operated, is pinned to rock-shaft *H*, to which is keyed arm *J*. Pivoted to *J* is a pawl *K* engaging the teeth of ratchet *L*, which revolves loosely on shaft *H*. This ratchet *L* controls the movement of locking finger *E*. The

parts are shown in their normal or locked position in the engraving.

As the handle *G* at the right of the engraving is pulled toward the observer, arm *J* at the left of the engraving is raised, carrying the ratchet wheel around in the direction of the arrow shown. This allows flat spring *M* to drop over the ratchet tooth, permitting helical spring *O* to raise latch *E* and thus leave the wheel free. The continued movement of the hand-lever and of rock-shaft *H*, by means of gear *N*, intermediate pinion *P* and gear *Q*, causes the indexing pawl *R*, pivoted to the latter and acting on the head of the bolt *C*, to index the wheel one step. Just before reaching its new location the new tooth of ratchet wheel *L* coming up, bears down on the top of spring *M*, pressing latch *E* into place against the tension of coil spring *O*. By this means the wheel is locked in position.

When the operator pushes the handle *G* back again to its position of rest, the pawl *R* is retracted into position to act on the next bolt head for the next indexing. Star-wheel *L* remains stationary on this backward movement, being prevented from revolving by the notch on the top of the tooth into which spring *M* fits. Pawl *K* on its return engages with the next tooth of this wheel, ready for the next indexing operation.

A slight rotary adjustment of dividing wheel *B*, independent of this indexing mechanism, is required for the feeding of the machine. This is accomplished by the end movement of latch *E*, which is pivoted in slide *S*. This latter is pressed to the right by spring plunger *T*, and is adjusted positively in the other direction by feed-screw *U*, which is finely graduated to permit accurate adjustment. The accuracy in indexing obtained by the use of a wheel thus made was required to bring the finished cutters within the very narrow limits allowed for them in the final inspection.

R. E. F.

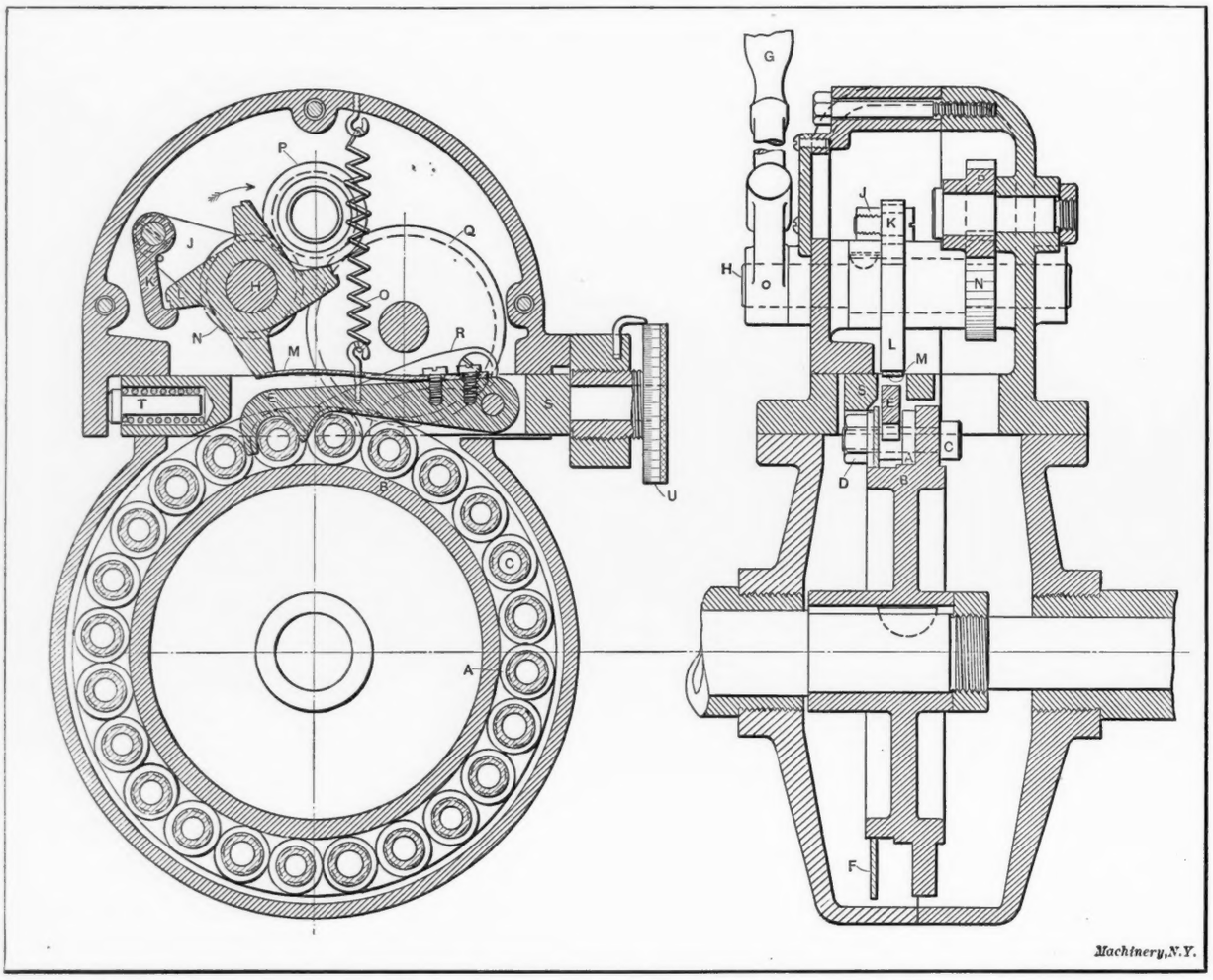


Fig. 2. The Indexing and Feeding Mechanism of the Fellows Gear Cutter Grinding Machine, in which the Dividing Wheel is used

EXPLOSION GAS TURBINES

In the March, 1907, and July, 1908, issues of MACHINERY, engineering edition, articles were published on practical results obtained with actual operative gas turbines in France. These articles consisted of abstracts from accounts published in *Cassier's Magazine*. The same magazine some time ago published additional information relating to recent developments in this field.

During the past year there has been built in Paris, by Mr. Karavodine, an explosion gas turbine developing about two horsepower; the machine has been operating with regularity, and recent tests have been undertaken from which the following data are obtained. In the Karavodine explosion gas turbine there are four explosion chambers, the products of the explosions being directed through four nozzles upon a single turbine wheel. The wheel is of the De Laval type, about six inches in diameter. This wheel makes 10,000 revolutions per minute, corresponding to a peripheral velocity of about 260 feet per second. The gasoline consumed per horsepower-hour amounted to 4.93 pounds. The machine gave 1.6 brake-horsepower, and the frictional losses were determined by the experiments to be 0.5 horsepower, so that the actual indicated horsepower was 2.1. In considering the availability of a machine of this type, there are some considerations other than fuel consumption. The continuous turning effort is often desirable, and considering the small size of the machine, the results were not unfavorable. The absence of a compressor and the corresponding reduction in weight and size are some of the advantages of the machine over previous types. Of course, the gas turbine is not yet a practical machine, but it is interesting to note the progress being made.

* * *

Don't dry freshly applied blue vitrol by brushing the piece of work against your overalls or apron; it destroys the fabric.

CUTTING SMALL SPUR GEARS IN SPECIAL SEMI-AUTOMATIC MACHINE

By E. H. WEISS*

When it is necessary to cut a large quantity of small gears of say 80 millimeters (3 5/32 inch) diameter, it is a job of some delicacy if it is necessary to do the work accurately and economically. This condition is met with periodically in our factory, particularly in the manufacture of small gears for the magnetic calls for telephone service. These gears are first turned on the outside in gangs while they are held between two clamping plates, thus making the periphery true with the bore which is sometimes slightly eccentric. As we possessed but one small and unsuitable sawing machine, it was decided to cut the gears and pinions (the latter also being of brass but only about 20 millimeters in diameter) by mounting

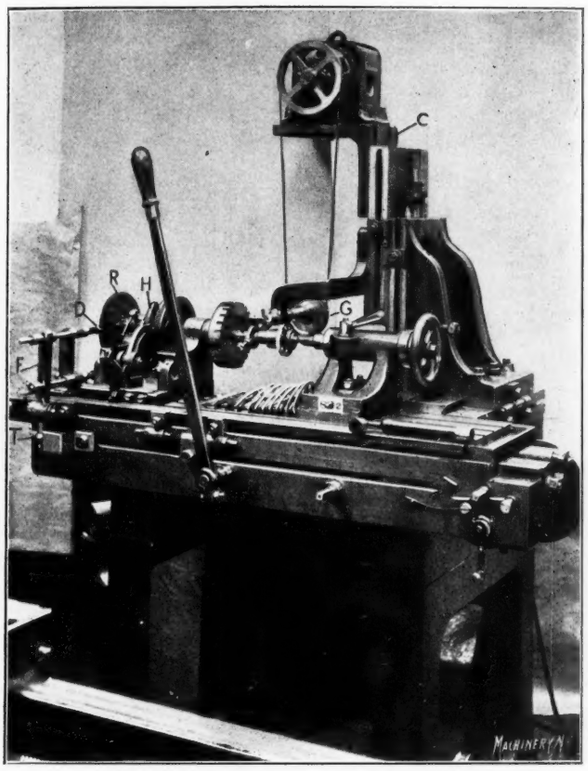


Fig. 1. Machine for Cutting Small Spur Gears, with Automatic Indexing Mechanism and Hand Lever Feed

them in gangs of eight or ten between the dividing heads of an old milling machine.

Two difficulties presented themselves: First, the maximum speed of the cutters was 1,800 revolutions per minute, which was not sufficient to finish the surface of the teeth properly without reducing the feed of the table, which would have increased the cost of the work; furthermore, as the platen was fed by hand, naturally it was difficult to feed it uniformly and with the required feed reduction. Second, the pressure necessary to hold the gear blanks together produced a slight curvature at the center which, in conjunction with the distortion due to the pressure of the cutter, caused the depth of the teeth in different gears to vary. It was then decided to mount the cutter on a special arbor which could be run at the required speed, and furthermore, to render the indexing automatic (the dividing was intended to be controlled by the to-and-fro movement of the lever *L*). The cutter-head was removed and on the vertical platen *P*, as shown in the accompanying illustrations, there was bolted a bracket *B* having two arms to support the cutter arbor. The latter, which revolved between centers, could, without difficulty, be driven at a speed of 3,500 revolutions per minute. Besides the cutter, this arbor carried a pulley *G* having a V-shaped groove. It was out of the question to drive this pulley from the driving shaft of the machine, for that shaft revolved only 150 revolutions per minute, therefore, it would have been necessary to have had a series of belts and pulleys which would probably have become heated on account of the high speed. It was decided then to drive the cutter arbor by means of a small motor. In order to avoid having a tightener on the driving belt, a large bracket *C* was fixed to the upper part of the slide *P*, and this bracket supported a shunt motor, on the armature shaft of which was fastened a grooved driving pulley. Since the cutter arbor is adjusted up and down with the slide *P*, the distance between the centers of the two pulleys, of course, is always the same.

The method employed to automatically effect the indexing of the dividing wheel is as follows: On the back of the dividing head a bronze wheel *R* is keyed, which is provided with either the same number of teeth, or a multiple of the number of teeth in the gear to be cut. The indexing of wheel *R* is effected by a dog *E* which has an adjustable movement, per-

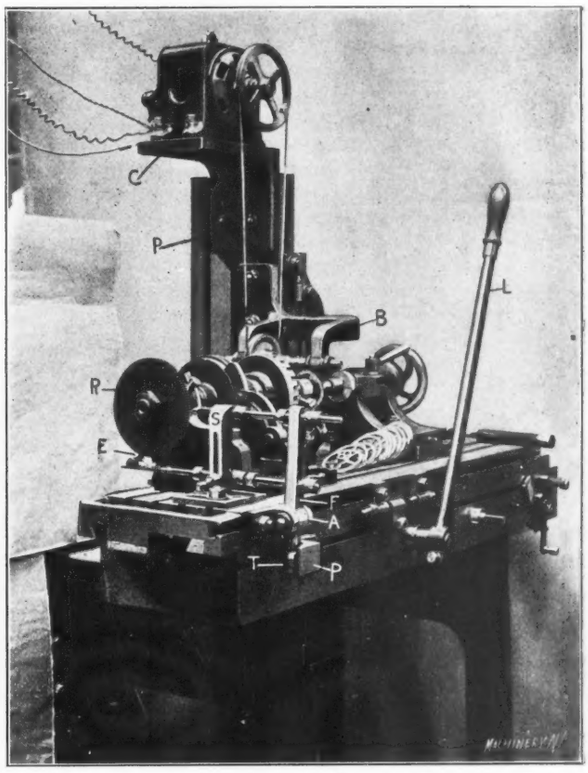


Fig. 2. Another View of the Spur Gear Cutting Machine

mitting the indexing of one or several teeth. After wheel *R*, and with it the work, has been indexed, the finger *D* which moves with *E*, enters a tooth space in wheel *R* thus locking it in position. The stems of parts *E* and *D* both slide in the same support *S*, and their backward movement against the pressure of coiled springs bearing against an abutment, is effected by a slotted lever *F*, which is pivoted at *A* and carries at its lower end a roller *T*. The base of the machine is provided with a wedge-shaped dog *P*, which is fixed in place. At the end of the movement of the table, that is to say, when a tooth has been finished, the roller *T* is displaced by the wedge-shaped surface on *P* thus effecting the movement of lever *F*, and through it that of stems *E* and *D*.

After experimenting, it was found that the work spindle needed to be braked more or less (depending on the number of holes being indexed) to check the table at the end of its movement. To effect this, a fiber brake *H* was provided, which supplied more or less pressure on a disk keyed to the spindle by means of an arm held down by spring pressure.

After the wheels are once placed on the arbor, the workman, who under the circumstances may be a common laborer, has only to move lever *L* back and forth and he does not need to occupy himself with the details of the cutting action. The work is finished when it has made a complete revolution. The movement of lever *L* can be very rapid, as the cutter, because of its speed, does not rough up the work.

As previously stated, this gear-cutting operation is only re-

* Address: 2 Rue des Entrepreneurs, Paris, France.

quired periodically, though several thousand gears are cut at a time. When the milling machine is not required for this work it is only necessary to remove the two heads, the bracket *C* and the arm *B*, when the machine may be used as an ordinary milling machine after the vertical or horizontal head has been replaced on the platen *P*.

* * *

"COST OF POWER" DEFINED

"Twenty-five years ago, the expression 'cost of power' was fairly well defined as meaning the yearly cost per indicated horsepower, if produced by steam; or power on the wheel shaft, if produced by water, for ten hours a day and about 308 days a year, or for 24 hours for the same number of days. This was fairly well understood by those who had to deal with these matters and who gave the matter any thought." This was the statement made by Charles T. Main and F. M. Gunby in their paper entitled "Cost of Power for Various Industries Under Ordinary Conditions." Continuing, this paper, which was recently read before the Boston Society of Civil Engineers, the authors go on to say:

"Since that time when mechanical transmission of power by shafting, belting, ropes, etc., were about the only methods in use, there has been developed the electrical transmission of power now so commonly in use, with new units of power as electrical horsepower, and the kilowatt, which is equal to 1.34 electrical horsepower. There also has now come into common use the steam turbine, for which there is no indicated horsepower, the measurements of power being either in brake horsepower, electrical horsepower, or kilowatts. There is the power produced by water wheels, which is gross horsepower, net horsepower at the wheel shaft, and when changed into electrical power, electrical horsepower and kilowatts.

"To-day the statement, 'cost of power,' unless clearly defined, may mean one of many things, and the men who are used to thinking in indicated horsepower are sometimes at a loss to know what is meant when the cost is stated as so much per kilowatt, delivered. It must be translated back into indicated horsepower or its equivalent, before there is any definite impression made on their minds.

"There is another source of great confusion because, during this period of time, there have been developed industries like electric lighting and street railway plants, in which the load is extremely fluctuating, in which, therefore, the cost per horsepower of unit of product is more and cost of plant more than for steady loads. Now that electrical transmission has been developed so that the current can be transmitted and used at a distance, it must be sold as electric current, delivered, and if a price is quoted to a mill manager at 32 dollars per kilowatt, delivered, he says: 'How much is this a horsepower?' and you answer, '24 dollars.' He then says: 'I can beat that in my engine,' and when he says it he is thinking of indicated horsepower at about 20 dollars a year per horsepower, with no allowance for friction loss in the engine or transmission to the same point where the electric current is delivered.

"If lighting current is offered to him at 3 dollars and 20 cents per kilowatt hour he says: 'How much is that a year?' 'For 3,000 hours it is 96 dollars a kilowatt, or 72 dollars a horsepower.' 'Well,' he says, 'that is outrageous when we produce at 20 dollars a year per horsepower.'

"It may be possible that he can beat the figures presented to him, but there is a reason for the discrepancy between his conception of what prices ought to be, and what they are.

"The cost of power and the value of steam and water power to the various industries varies between very wide ranges. Steam power costs the most per unit of power when produced in small amounts, and the cost is increased for fluctuating loads and when used for purposes where the load factor is small. By 'load factor' we mean, in this particular instance, at least, the average output in per cent to the full load capacity of the plant. Loads with a small load factor are obtained in electric lighting and street railway plants, in which cases there is generally no use for the 'by-products of power.'

"Steam power costs the least per unit of power for comparatively steady loads, and the cost is still further reduced where there is use for exhaust steam or the overflow water from the condenser. Such conditions as these are found in colored textile mills. Another example of the low net cost of power is in steel mills where the waste gases of the furnaces are used, either for the production of steam or directly in gas engines. Between these extremes there are various industries for which the cost of power will vary greatly."

* * *

ROOTS BLOWER PISTON PROFILES*

The design of the profile of the pistons of a Roots blower presents great difficulties to the novice who attempts to arrive at a correct form by the process of "trial and error," or the complicated method of making tracings of the pistons in twenty or thirty different positions on one piece of paper. The matter is very simple, however, when analyzed, and the writer believes the method of drawing the profiles, given herewith, to be original. It was at any rate discovered by him recently, when the design of some Root's blowers came into his hands, and the results appear to be excellent. A favorable point is that all the curves are parts of circles, which greatly facilitates the machining of the faces by making it possible to rotate the work on centers when planing.

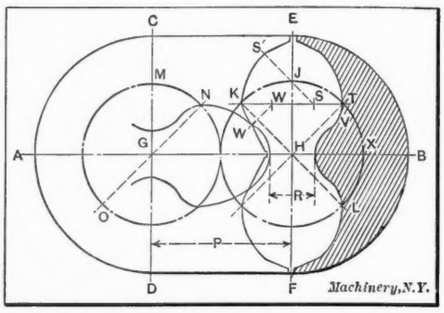


Diagram Illustrating Method of Laying out Root Blower Pistons

In a blower of this design the air space available is about 60 per cent of the area swept out in one revolution of the pistons; *i. e.*, the area *X*, Fig. 1, equals 60 per cent of the area of the half circle *E F*. In calculating the output, an efficiency of 70 per cent can be allowed, so that $L = 4 \times A \times R \times 0.7$, when L = length of piston in feet, A = area of one air space X in square feet, R = revolutions per minute. The diameter of the pistons is, of course, made sufficient to give a proportionate length of, say, 2 diameters. The distance P between the centers (see illustration), equals 0.6 times the diameter of the piston plus ⅛ to ¼ inch for clearance. This makes the width at the narrowest part $R = 1/5$ of the diameter *E F*, and it may not be less.

To lay out the profiles, set down the horizontal and vertical center lines *A B*, *C D* and *E F;* and from the centers *G* and *H* strike the pitch circles *J K L* and *M N O* with radius $= ½ P$.

It will be seen that at the points *K* and *N* the profiles of pistons cut the pitch circles. These points are found by drawing a line at 45 degrees from the centers *H* and *G*. Through the point *K* draw a line *K T* parallel to *A B*. From center *S* with radius *S K* = radius of pitch circle, describe the arc *K S'*, placing center *S* on the line *K T*. From center *W* with the same radius describe the arc *T E*. From center *S* describe arc *T V*, and from the center *W* describe the arc *K W'*.

This produces one pair of faces, and the opposite pair is produced in a similar way. A radius must now be found such that with the center on the line *A B* an arc may be struck connecting the inner part of the faces and the outside of the center boss. The useful part of the curving faces thus produced lies within the angles formed by the lines *S S'* and *W W'*, and the line *K T*. These lines *S S'* and *W W'* are struck at 45 degrees from the centers *S* and *W*. The useful part is all of the faces that need be machined, though in practice it is as well to extend it ½ to ¾ inch beyond.

The outer part of the pistons should be formed into a rib which may project ¼ to ⅜ inch, and the base of this rib may be joined by a straight line to the point on the face at which the machining finishes. It may be stated that this construction does not produce perfect contact at all times between the faces, but the error is negligible. Allowance must, of course, be made for clearance between the pistons.

* R. Hampton, in the *Mechanical World*, December 24, 1909.

DON'TS FOR MACHINISTS*

By H. E. WOOD†

Don't run an emery wheel that is on a shaky machine.

Don't use a hand reamer for power reaming.

Don't run cutters backward in a milling machine.

Don't finish a milling machine job with dull cutters.

Don't put up pulleys unless they are properly balanced.

Don't leave set-screws sticking out of shafting collars.

Don't use one emery wheel for all kinds of grinding work.

Don't set the stroke on a shaper longer than is necessary.

Don't put on a belt with the flesh side next to the pulley.

Don't file holes oblong to let a bracket up to its place.

Don't force an emery wheel on an arbor; it should be an easy fit.

Don't let your milling machine cutters slip around on the arbor.

Don't work on any machine if the countershaft hangers are loose.

Don't believe that emery wheels are the only abrasive wheels made.

Don't put wooden wedges under the hanger feet without nailing them.

Don't make a new piece just like the old piece when making repairs.

Don't screw the clamping nut too tight against an emery wheel; it is dangerous.

Don't work under a cracked pulley; it should be patched or scrapped.

Don't leave anything loose lying overhead where machinery is running.

Don't bear on an emery wheel too hard; it will only cut so fast anyway.

Don't fail to have all oil cans marked so that the kind of oil in them is known.

Don't try to put in lag-screws without first boring pilot holes for them.

Don't put lag-screws into hardwood timber without a good heavy grease on them.

Don't forget that fast speed is better than slow speed for slotting saws.

Don't run a milling cutter against the table or vise jaws and then deny it.

Don't forget that very high speed should be used to make brass cut nicely.

Don't think that locomotive work is altogether like stationary engine work.

Don't get your shirt or frock sleeve close enough to touch a running drill.

Don't forget that sheet steel has an end grain, similar to a piece of board.

Don't make center punch marks to work to, when you can see your scratch lines.

Don't try to make a straight hole in a spongy piece of cast iron with a drill.

Don't forget that large flat castings will bend with their own weight.

Don't run an emery wheel any faster than one mile a minute at its cutting surface.

Don't forget that a taper reamer makes a good backing-off tool in punch and die work.

Don't forget that it is an impolite question to ask the new man where he worked last.

Don't fail to make allowances for the sag of your shafting when putting up a line shaft.

Don't neglect an emery wheel until the face is entirely clogged full of metal and dirt.

Don't put up a chain hoist and use it without making sure that it will hold more than the load.

Don't put up overhead shafting without making provision to catch or absorb the surplus oil.

Don't use flanges or washers on the emery-wheel arbor without a slight concave to their face.

Don't allow work to rattle loose on the lathe centers, except when filing or polishing.

Don't put lag-screws through a board, plank, or timber, without washers under the heads.

Don't set the outer support for a milling machine arbor up tight to the nut, but leave a little end play.

Don't mount an emery wheel without first tapping it lightly, to see if it is sound or cracked.

Don't start up a milling machine unless you have the arbor in tight enough so that it will not slip.

Don't forget that canvas or leviathan belt works better in some places than leather or rubber.

Don't use too much belt dressing as too much is worse than none at all; besides it is expensive.

Don't use a large emery wheel on a small machine, or a small one on a large machine; it does not pay.

Don't try to start a milling cutter into a piece of steel that has the rolling mill scale still on it.

Don't cross your belt laces on the side next to the pulley, for that makes them cut themselves in two.

Don't forget that a power-transmitting belt will almost invariably go to the tightest point it can find.

Don't let the full weight of a power hacksaw be on a square or flat piece of work when the saw is started.

Don't forget that you can cut flat, square and round pieces of stock in a power hacksaw at the same time.

Don't try to get along with only one center-punch, or scratch awl, but have two or three; you'll need them.

Don't forget that there is a difference in letting a bracket "up to its place" and "back to its place."

Don't put a large washer on one side of an emery wheel and a small one on the other side; it is dangerous.

Don't bolt a rough casting down on a milling machine table or planer bed; it is better to put brass shims between them.

Don't saw a piece of steel nearly through from one side only, and then break it the rest of the way.

Don't start to do a drilling job unless the drill is tight enough in the chuck so that it can't slip around.

Don't forget that a shaft bearing will only take so much oil; any more than that amount will be useless.

Don't fail to leave a liberal allowance for expansion and contraction (or end play) in a line, or jack shaft.

Don't screw the bolts up too tight on one side of a pulley; both sides should be tightened together.

Don't blow dust from a hole or a corner unless you expect it to float back and get into your eyes.

Don't put a countershaft overhead without first putting it together on the floor, to see that it goes all right.

Don't use machine lubricating oil on taps, drills, or any cutting tools, and lard oil to lubricate a machine with.

Don't think that it is absolutely necessary to be just as precise and neat in repair work as you should be in new work.

Don't let a cone pulley get gummed up with belt grease; in fact, it is better not to use belt grease on cone belts.

Don't believe that it is economical to save emery wheels by neglecting to keep them trimmed and sharp.

Don't fail to get a little originality into your head, and try to reason out the why and wherefore.

Don't spit on the floor, because there is not a sufficient amount of iron on the floor to kill the tuberculosis germ.

Don't be reluctant to use the emery wheel dresser, as it has much the same effect as a file has to a carpenter's hand saw.

Don't mount an emery wheel carelessly, because ninety per cent of the emery wheel accidents come from this carelessness.

Don't think that a shaft must be absolutely level to run correctly, for the alignment of the centers is the most important.

Don't hesitate about asking your foreman questions; it is better to make him mad that way than by spoiling a piece of work.

Don't place pulleys so close together that there is not room enough for the full width of their belts to go down between them.

Don't forget that you may resort to many tricks in repair work that would not be tolerated for a minute in manufacturing work.

---

* For Don'ts previously published in MACHINERY, see "Don'ts for Pattern-makers," January, 1910, "Don'ts for Screw Machine Operators," November, 1909, and "Don'ts for Draftsmen," with accompanying references, August, 1909.

† Address: 182 North 4th St., Newark, N. J.

Copyright, 1910, by THE INDUSTRIAL PRESS

Entered at the Post-Office in New York City as Second-Class Mail Matter

MACHINERY

DESIGN—CONSTRUCTION—OPERATION

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS

49-55 LAFAYETTE STREET, CORNER OF LEONARD
NEW YORK CITY

Alexander Luchars, President and Treasurer
Matthew J. O'Neill, Secretary

Fred E. Rogers, Editor
Ralph E. Flanders, Erik Oberg, Franklin D. Jones, Ethan Viall,
Associate Editors.

The receipt of a subscription is acknowledged by sending the current number. Checks and money orders should be made to THE INDUSTRIAL PRESS. Money enclosed in letters is at the risk of the sender. Changes of address must reach us by the 15th to take effect on the following month; give old address as well as new. Single copies can be obtained through any newsdealer.

We solicit exclusive contributions from practical men on subjects pertaining to machine shop practice and machine design. All accepted matter is paid for at our regular space rates unless other terms are agreed on. All copy must reach us by the 5th of the month preceding publication.

MARCH, 1910

PAID CIRCULATION FOR FEBRUARY, 1910, 25,687 COPIES

MACHINERY is published in four editions. The practical work of the shop is thoroughly covered in the Shop Edition, $1.00 a year, which comprises approximately 700 reading pages and 36 Shop Operation Sheets, containing step-by-step illustrated directions for performing 36 different shop operations. The Engineering Edition, $2.00 per year—coated paper $2 50—contains all the matter in the Shop Edition, including Shop Operation Sheets, and about 300 pages additional reading matter, and forty-eight 6 x 9 Data Sheets filled with condensed data on machine design, engineering practice and shop work. The Foreign Edition, $3.00 a year, comprises the same matter as the Engineering. The Railway Edition, $2.00 a year, is a special edition including a variety of matter for railway shop work—same size as Engineering and same number of Data Sheets.

A POWERFUL COMBINATION

Considerable space has recently been used by some trade journal publishers to deny the existence of a trust or combination of their properties. This was followed by a statement signed by Messrs. Charles G. Phillips, I. A. Mekeel, John A. Hill, James H. McGraw, W. H. Taylor, E. A. Simmons and Robert Tinsman, as owners and managers of eighteen important trade journals in the iron, steel, hardware, metal, machinery, mining, power, steam and street railway, electrical, boot and shoe, and dry goods industries, explaining the purpose of a combination of the above interests "to conduct complete campaigns for advertisers in every important line in the trade or technical press or the general publications. . . . The power of this organization for the general improvement of advertising effort is immense in its possibilities."

The power of this organization is beyond question. It is a combination of five powerful organizations in the trade paper field, comprising most of the leading journals in the industries represented; and it is idle to deny that the power referred to will be exercised to secure advantages for the publications in the combination to the exclusion of their competitors. That is what the organization is for.

Without seeking to make capital out of this situation or to exaggerate its importance, we may say that such a combination is a menace to trade journalism, because its object is to weaken if not to kill the independent journals in those fields. Aggressive competition is fully as desirable between trade journals as in any other line of business.

* * *

THE FUTURE OF THE AUTOMOBILE INDUSTRY

A good many manufacturers of machine tools and supplies who are selling from fifty per cent to one hundred per cent of their product to the automobile trade are asking themselves how long the demand will continue, and if it will drop off as suddenly as the bicycle trade did. We think not.

Bicycle riding was a craze that went through a family like the measles. There were five members of the writer's family and we had five wheels. That was ten years ago, and since then a new generation of children has grown up, but they don't ride wheels. The industry is now reduced to a commercial basis, and not one rider in a hundred uses his wheel for pleasure.

Bicycling as a fad began to expire when it became commercialized, and all sorts of people took to wheeling. The future of the automobile industry, as we all agree, lies in the adaptation or development of cars to commercial uses—not accomplished yet because manufacturers so far have been unable to supply the demand for pleasure cars, and also doubtless because of the smaller margin of profit between a luxury and a strictly commercial proposition.

After the existing and projected automobile works are equipped, we shall have some let-up in the demand for machine tools for that purpose, but the skill of our mechanics probably will develop the automobile industry gradually and conservatively until it becomes as safe and permanent as any other.

* * *

SIGNS ON FACTORIES

There are many forms of advertising a manufacturing business, and not the least valuable is by means of harmonious signs on the buildings, especially when they are located within sight of a railroad. Some large and prosperous concerns neglect signs and consequently lose an opportunity of making their business known to the traveling public. An Industrial Department circular issued by the Erie R. R. places the subject in another light which is worth considering by the public-spirited manufacturer: "Signs make business. . . . Apart from all business interests, a sign on a factory is an ethical courtesy to the traveling public."

An ethical courtesy in this respect is equivalent to the answer to a stranger's civil inquiry on the street. The railway traveler is prompted to ask what the industry is that he sees housed in some fine large buildings, and the plant should answer his question with a sign. Not only is a sign an ethical courtesy, but it often is a great time-saver. A traveling man or a customer visits a place new to him, with but little time to spare between trains, and loses many valuable minutes in locating the concern he desires to visit, which might be saved if he saw its sign from the approaching train.

Manufacturing concerns should display their name and business, when practicable, prominently on their factory buildings for the reasons just given; and, finally, a plain but artistic sign is not only a good advertisement, but it gives an air of prosperity to a plant, especially if the buildings and grounds are well-kept.

* * *

THE VALUE OF THE TECHNICAL WRITER

If it were possible to follow in detail the evolution of our highly-developed mechanism and to trace to their origin the superior methods employed in the modern shop, the credit given to the technical writer, and his status in the industrial world would probably be much greater than is apparent on the surface. In the advancement which is constantly taking place throughout the entire realm of mechanics, there is reflected to a considerable extent the work of men who have given publicity, through the printed page, to valuable knowledge they have acquired in the school of experience. And while all that is published is not valuable, it should be remembered that a large part of the technical matter which appears in the columns of this and other publications, as well as that which is presented in book form, has a value often far in excess of its apparent merit. The description, for instance, of a certain method or mechanism may suggest an idea which results in the adaptation of the same principle in other ways for other purposes; and if it were possible to trace some of the most valuable pieces of mechanism or inventions back to their origin in many instances we should find that the technical writer was largely responsible for their development. If all technical literature were to be suddenly blotted out of existence and no more contributions were made to it, say, in a generation, the resulting retrogression would reveal, as nothing else could, the value of the technical writer. So the man who records the knowledge that he gathers through the years and transmits it by publication to thousands of readers should be treated as a member of that class to which is largely due the advancement of industrial knowledge.

HOPE AS A NATIONAL ASSET

It has been a matter of perennial comment that the American workman has characteristics which are all his own. He stands preeminent among all the great industrial peoples in alertness, originality, conscientiousness and ambition; and in consequence he leads the world in value of product per individual. This does not mean that he is molded of finer clay than his European brother, for every incoming ship-load of immigrants shows that the contrary is true. A few months in this country, or a few years at the most, often work wonders in the stolid, unimaginative foreigner; and the ability to thus inspire the stranger within our gates is due to our industrial development in the past, and the hope that it maintains for the future.

One basis of the efficiency of the American workman is *hope*, and that hope springs from the opportunity the individual is offered in this country. So long as he sees that faithfulness and intelligence command living wages—that exceptional ability is appropriately rewarded, and so long as he feels that no congenital social barriers exist between himself and his employer—so long is our industrial position secure.

There are, unfortunately, evidences of danger ahead in this direction. Successful employers have sometimes forgotten that they or their fathers were themselves workmen but a few years ago. The growth of monopoly and privilege has often robbed master and man alike of the just rewards of their labor; and sometimes this growth has borne its evil fruit of suspicion, recrimination and deadly warfare. Fortunately, these conditions are still sporadic. It is the duty and privilege of employer and employe alike to join hands in rooting them from the soil of our national life. It is, in fact, more than a duty and privilege—it is a necessity.

* * *

FORMULAS FOR COMBINED BENDING AND TORSION

Several formulas have been given by various authorities to be used for obtaining what is called the ideal moment of combined bending and twisting moments. Some of these formulas vary widely, and there does not appear to have been any sound practical basis for the adoption of many of them. Rankine gives a formula:

$$M_I = \frac{1}{2} M_B + \frac{1}{2} \sqrt{M_B^2 + M_T^2}$$

in which M_I = ideal or combined moment,
M_B = bending moment,
M_T = twisting moment.

St. Venant gives the following formula:

$$M_I = \frac{3}{8} M_B + \frac{5}{8} \sqrt{M_B^2 + M_T^2}$$

This formula is also given in a slightly modified form in Hütte's "Des Ingenieurs Taschenbuch." In 1900 Mr. J. J. Guest published the results of some experiments made by him, on the strength of which he gave the following formula as expressing the relation of combined twisting and bending:

$$M_I = \sqrt{M_B^2 + M_T^2}$$

It will be seen that this formula differs very considerably from that of Rankine and St. Venant, especially for increasing twisting moments. For bending moments alone, the three formulas give equal results, but as the twisting moment increases, the Rankine formula allows a steadily increasing twist to take place, so that at the point where the stress is entirely a twisting stress the permissible torque by the Rankine formula becomes twice as great as that obtained by the Guest formula. It seems evident that the Rankine formula gives too high values for very large twisting moments. The St. Venant formula is a mean between the Guest and the Rankine formulas.

Experiments have recently been carried out by Mr. C. A. M. Smith and also by Mr. W. Mason, reports of which have been read before the Institution of Mechanical Engineers, Great Britain. The experiments made by Mr. Smith confirm the soundness of the Guest formula so far as mild steel is concerned and this formula may, therefore, be assumed to agree with practical experience. Mr. Smith also undertook experiments on self-hardening steels and nickel steels, but these experiments were unsatisfactory and no definite conclusions could be drawn from them because the material gave exceedingly variable results. Specimens cut from the same bar, even, did not give the same results in two consecutive tests. The formula is applicable to machine steel, however, with which material the machine designer is almost exclusively concerned when questions of combined bending and twisting stresses demand his attention, and the fact that the other materials mentioned do not give uniform results when tested indicates that it is not possible to obtain a universal formula for them.

* * *

IMITATION OF MACHINE TOOLS

American machine tool builders frequently complain of the imitation of their machines by European manufacturers. In a few instances it appears that American machine tools have been copied outright, but in most cases the copying consists of using the principal ideas embodied in the American design, adapting them in minor details to European requirements, and introducing such improvements as appeal particularly to European users. It is evident, however, that even in such cases, where the imitation embodies certain changes and improvements, the American manufacturer who has spent a great deal of time and thought in developing the original design cannot look with equanimity upon the practice of the European builders who thus make use of his ideas; but whenever no patent rights are involved, it is not possible for the American manufacturer to interfere.

A most interesting point in this situation is that while American manufacturers often complain about their machines being copied by European manufacturers, there is but comparatively little complaint against exactly the same practice in this country, although the cases in which American manufacturers copy the designs of their competitors are far more numerous than those in which European manufacturers are the imitators. A study of representative machine tools will show that of each class there are but a few original types differing radically from other machines of their kind, these types having been developed by a dozen or so progressive American machine tool builders. Improvements on such machines have been then introduced by various other manufacturers in adapting them to special conditions, exactly as has been done in many cases by the European manufacturers who are stigmatized as imitators.

While we are not undertaking a defense of imitators, the practice of incorporating the principal points of advantage in another design and adding to them a manufacturer's individual ideas, does not necessarily deserve unqualified condemnation, for without this custom the progress of civilization would have been impeded. The whole progress of the world is based upon the imitation and adaptation of the best in previous developments, and in adding to it new features of increased utility. In the manufacture of machines, this feature has been highly important in the evolution of the art of machine construction, and it is necessary to consider these points, not from the narrow standpoint of the individual, but from the larger one of general progress.

If we prefer, however, to look upon this question from a more limited point of view, we must still recognize that the superiority of one machine over another does not lie solely in the embodied features of design; it depends also largely upon the workmanship, material and processes of manufacture. The machine builder who can make the best machine at the lowest price, due to superior organization and management, will always take the lead of his competitors, no matter if they do imitate his designs. The fact that his machines are being imitated is one of the surest indications of his success. Fear of imitation is often an indication that there are defects in the organization and management which would make successful competition possible unless a trade secret, patent, or other partial monopoly were involved. The man who can afford to let others imitate him has built his organization on the firmest foundation. He may regret to see competitors take advantage of his inventive ability, but their competition will only prompt him to still greater effort—to prove that he has not yet reached his limitations.

LAYING-OUT AND ALIGNING OPERATIONS ON MACHINE TOOLS—2

By ALFRED SPANGENBERG*

In the previous installment of this article a number of special tools and devices used in the laying out and aligning of work were illustrated and described. The use of templets and gages in this class of work was indicated by several examples. In the present installment operations of this kind performed without special tools will be dealt with.

Laying-out and Aligning Operations without the Use of Special Tools and Appliances

In the absence of special tools and appliances for laying-out and aligning operations, the principal points to be observed

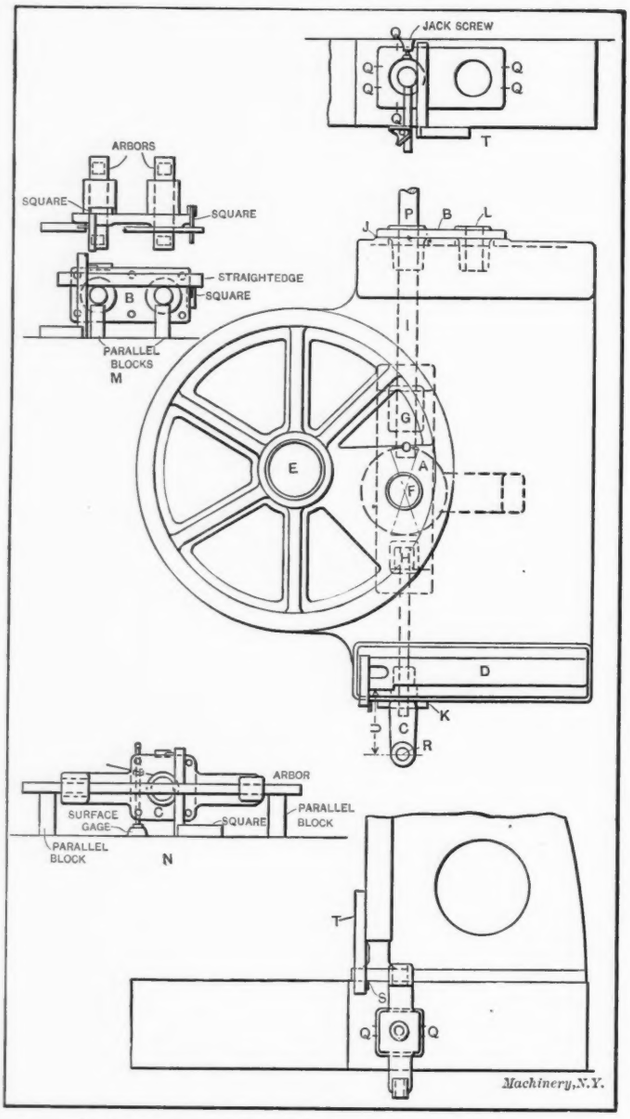


Fig. 8. Laying-out and Aligning Operations on a Vertical Boring Mill of the Spur Gear Driven Type. By the Methods shown, no Special Gages or Tools are required

are the selection of a proper starting point from which to lay out all dimensions, the employment of efficient means to compensate for the deflection in horizontal aligning arbors when the bracket seats lie in a vertical plane, *i. e.*, when it is impracticable to place the bed of a machine in such a position that the bracket seats will lie in a horizonal plane and thus carry the bracket members unsupported; and the avoidance of assembling all the correlated members together for the laying-out operations.

The first two points brought out above are exemplified in the aligning operations on a vertical boring mill of the spur pinion driven type, which is illustrated in Fig. 8. The operations involved are the alignment of the driving pinion bracket *A*, the driving shaft bracket *B*, the feed shaft bracket *C*, and the housings; only one housing *D* is shown. The hubs on the brackets have clearance in cored holes in the bed. It is the general practice to bore out the table spindle hole *E*, and table gear pinion hole *F*, by means of a boring jig, previous to aligning the brackets; hole *F* in the bed is then used as a starting point for the aligning operations.

For convenience in setting bracket *A*, which forms the lower bearing for the table driving pinion, and also carries inner bearings *G* and *H* for the driving and feed shafts, the bed casting is turned bottom side up, the process being as follows: The table pinion is placed in position in its hole *F* for the purpose of centering the bracket; next the driving shaft *I* is put in place in its bearing *G*, and then the bracket is squared with seat *J* by means of a square held against the seat and the shaft. This setting is for marking off the bolt holes in the bed, and after the drilling and tapping is accomplished, the bracket is reset in the same manner as before and clamped by its bolts; then the dowel pin holes are drilled, reamed, and the pins fitted.

The next logical step is to turn the bed right side up and place reference lines on seats *J* and *K* respectively. A separate operation involves placing reference lines on the bracket members *B* and *C*. The reference lines represent, on each separate member, the outside diameter of the shaft used in aligning; then, in assembling the bracket members on the bed for the aligning operations, it is simply necessary to match the lines on the brackets with those corresponding on the bed. During this operation the brackets are supported on screw-jacks. This method of setting brackets illustrates the second point stated above, the employment of efficient means to compensate for the deflection in aligning arbors when the bracket seats lie in a vertical plane; another point of advantage, however, is that this method insures proper alignment of the shafts, any inaccuracy in the machining of the seats being immediately apparent when the members are assembled. For instance, another method of setting the driving shaft bracket would simply be to place the bracket in position on its shaft, support it on screw-jacks, and then shift the bracket around until a feeler indicated that all sides of the bracket were tight against its seat on the bed, attention being paid, of course, to the location of back-gear hole *L* with reference to the top of the bed. With this method it would be possible to have all sides of the bracket tight against the bed as just explained, but in the event of the bracket seat not being perfectly square with the hole, the shaft would be thrown out of proper alignment with reference to the planing on the bed and also to hole *G*.

Turning back now to the question of reference lines, the method of placing these lines on the driving shaft bracket is clearly illustrated at *M* in Fig. 8, while at *N* is shown the same operation on the feed shaft bracket; both cases are essentially the same. To place lines on the bed seat *J*, a surface gage is first set to the driving shaft at *O*; next the gage is moved to position *P* and the shaft jacked up until the surface gage indicates parallelism with the top of the bed; and then, after testing the shaft with a square on seat *J* to insure that the screw-jack is not holding the shaft out of alignment sideways, a combination square and an ordinary square are used as shown at *T*. Similar operations are involved on seat *K*. Permanence is given all reference lines by driving a thin chisel into the casting directly on the line. These lines are indicated in the engraving by the letter *Q*.

The housings are located on the bed with reference to hole *R* for the vertical feed shaft. Previous to placing the housings on the bed, however, lines are drawn at *S* on each housing and on the bed casting, which lines are in the same plane as the front face of the housings. This is accomplished in the former case by means of a straight-edge *T*, and in the latter case by laying off on the bed the correct distance from the center line of brackets *A* and *C*. In placing the housings on the bed the corresponding lines on each member are matched, and then the housings are moved so that measurement *U* is correct; this measurement is taken with a straight-edge and combination square. The housings are set for the pinning operations in the same manner. It may be of interest to state that the housings are first set on a large surface plate for the purpose

* Address: 951 W. 5th St., Plainfield, N. J.

of bolting on the arch casting and fitting the top-works, thus enabling the accomplishment of several operations simultaneously, as the cross-rail gibs also can be laid out at this time.

By observing the third principle laid down above, the avoidance of assembling all the correlated members for the laying-out operations, it is often possible to advance work that otherwise could not be accomplished. This point is illustrated in Fig. 9, which shows an oil pumping arrangement attached to an engine lathe carriage and driven by a shaft carried in bearings on the back of the bed. This outfit is special in its nature and is furnished as an attachment; considering this fact it will be apparent that the bed member is likely to reach the assemblers last, and therefore the work can be greatly advanced by laying out and fitting up the carriage members independently of the bed.

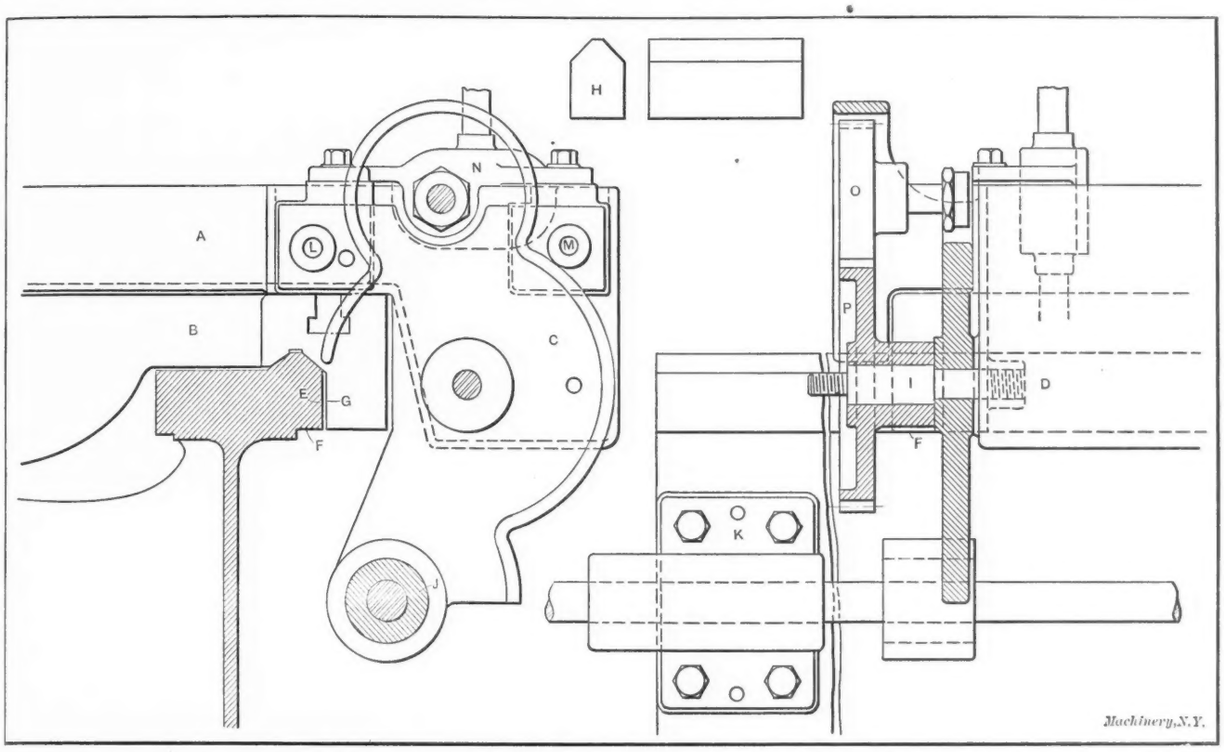


Fig. 9. Method of Laying Out and Aligning an Oil Pump Attachment on an Engine Lathe. Illustrating the Principle of Avoidance of Assembling all the Members together for the Laying-out Operations

After bolting the oil tank *A* to carriage *B*, its bolts fitting T-slots in the carriage, the oil tank is set and then dowel-pinned, the operations being so simple as to need no explanation. As bracket *C* is already bored out on a boring mill, the first laying-out operation involves the location of stud hole *D* in the oil tank. Since this hole must be laid out with reference to surfaces *E* and *F* on the bed (surface *G* on the carriage is merely planed for clearance) very effective use can be made of a jig consisting of a short bed section; but if this is not available, a gage block *H* similar to that used in planing the carriage, can be substituted. A graduated try square is used first on surface *E* and then on surface *F;* the measurements are read directly from the graduations. Next, the hole is drilled and tapped using a pneumatic drill, and then bracket *C* is clamped in place by the intermediate gear *I*.

The next operation involves the alignment of hole *J* with reference to surface *E*, the object being to provide standardization for the planing of shaft bearing *K* and its seat on the bed. This is accomplished by swiveling bracket *C* around, using stud *I* as a pivot, until a combination square and scale indicate that the measurement is correct. The slide of the combination square rests against surface *E*, while its base is held in contact with surface *F;* the scale is then used to measure from the combination square slide to the center in the hole. After the bolt holes *L* and *M* are located, drilled and tapped, bolts are entered and the bracket is reset for pinning; the clearance in the bolt holes permits of adjustment.

To set the oil pump *N* it is merely necessary to bring gears *O* and *P* into proper mesh. The driving shaft brackets on the bed, one of which is shown at *K*, are located as follows: A short arbor representing the driving shaft is inserted in the bearing hole, and then the measurement is taken from surface *F* on the bed. These brackets are located and drilled on the bed while it is under a radial drill for other drilling operations, and the bed is turned over on its side at this time for convenience. The dowel pin holes in the driving shaft brackets are not drilled until all the parts are assembled on the bed; then the final alignment is accomplished by moving the carriage close to each bracket alternately and slackening off the bolts, thus allowing the adjacent bracket to be self-aligned, after which the bolts are tightened for the pinning operations.

Laying Out Angles

In machine tool work it frequently becomes necessary to lay out angles, and as a general rule it may be stated that a much greater degree of accuracy can be obtained by the following methods than is possible by laying off angles with the ordinary bevel protractor made for machine shop work. The correctness with which an angle can thus be produced, however, naturally depends on the skill of the workman in working to the scribed lines and on the accuracy with which

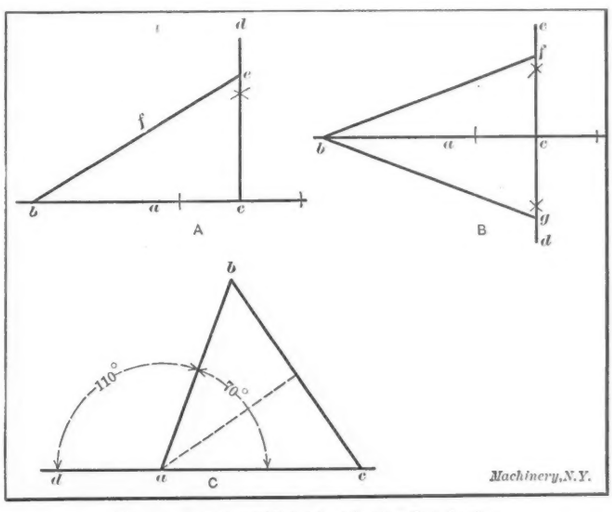


Fig. 10. Graphical Method of Laying Out Angles

they have been located. If it is not convenient to lay off the lines directly on the work, the given angle or taper may be laid off on a piece of sheet steel, which is then carefully filed to the lines scribed thereon.

Scribe a straight line *a*, as at *A* in Fig. 10; then make two very fine center punch marks, as *b* and *c*, on this line, as far apart as circumstances will permit. At *c* erect a perpendicular, as *cd*. The distance *bc* being laid off to some convenient dimension, take the tangent of the required angle and multiply the distance *bc* by this tangent, using a table of natural tangents. Then, on *cd* lay off as accurately as possible the product of *bc* and the tangent, marking it by a fine center punch mark as at *e* on the line *cd*. Scribe a line through *b* and *e;* the angle *ebc* will then be the required angle.

When the required angle is greater than 45 degrees, it is more convenient to use the method shown at *B*. Scribe the line *a* and on it lay off *bc* as long as convenient. At *c* erect the perpendicular line *de*. From a table of natural tangents, take the tangent corresponding to one-half the required angle; multiply the distance *bc* by this tangent and lay off the distance thus found on both sides of *c*, marking it at *f* and *g*. Join *f* and *g* to *b* by straight lines. The angle *fbg* is the required angle.

When the required angle is greater than 90 degrees, instead of laying off that angle, its supplement is laid off. Subtract the required angle from 180 degrees and lay off the angle thus formed. Thus, if the required angle is 110 degrees, lay off the angle *bac*, as at *C*, Fig. 10, equal to 180 degrees — 110 degrees = 70 degrees by the method illustrated at *B*. The angle *dab* is then 110 degrees. All other factors remaining as before, the accuracy attainable will be greater as the base line, as *bc*, at *A* and *B*, or *ac*, at *C*, is made longer.

The laying-out and aligning operations on machine tools require, as we have seen, a thorough understanding of the purpose of the various parts making up the machine, and the accuracy required in their alignment. Besides this, a general knowledge of elementary geometry is not only helpful but in many cases almost indispensable. The examples of aligning operations given in the present articles are, of course, intended to be primarily of suggestive value. Individual judgment will have to be used in each particular case, and definite rules cannot be laid down that would be applicable under all conditions. The general outlines presented above, however, and the simple methods given for the laying out of angles will be found useful in operations of this kind not only on machine tools but on all classes of machinery where the accuracy of the alignment of interdependent parts is necessary for the successful working of the machines.

* * *

At the meeting of the New York Electrical Society at the Engineering Societies Building, 29 West 39th Street, January 27, Prof. W. S. Franklin of Lehigh University lectured on "The Practical Applications of the Gyrostat." The lecture was made exceptionally clear by means of lantern slides and was illustrated by experiments. A working model of the Brennan monorail car was also exhibited in action. The points discussed by Prof. Franklin were, in particular, the physical action of the gyroscope exemplified by illustrations of the gyrostatic action of the fly-wheel of automobiles; gyrostatic action on board ship, and the Schlick device for preventing the rolling of ships at sea; and, finally, the application of the gyroscope to the Brennan monorail car. Prof. Franklin explained in a very clear and concise manner the principle of the gyrostat and showed how by simple means the action may be exhibited; for example, by simply rotating at a reasonably high speed a bicycle wheel having its rubber tire replaced by a lead rim and suitably mounted in a frame on a platform, it is possible for a person sitting on the platform to balance himself on but two supports or legs.

After the lecture a description of the Scherl gyroscope monorail car was read and also a communication from Mr. Frank J. Sprague relating to his own early ideas for the utilization of gyroscopic action. The general discussion was then opened by Mr. E. A. Sperry, who explained, in particular, the design and action of gyroscopic devices installed on board ship for preventing rolling.

ELECTRIC WELDING OF COPPER, BRASS AND ALUMINUM*

By A. E. BUCHENBERG†

The welding of brass, bronze and other alloys of copper is almost impossible as a forging operation. The fusing points of the several alloy metals are considerably below that of copper, and it becomes a very difficult matter to prevent the oxidization of these metals before the copper component has reached a welding temperature. While it is possible to weld copper and aluminum in the same manner as iron or steel by the forging method, the work is more or less difficult and requires a careful and skilled operator. Some of the difficulties are as follows: The welding temperature of copper is much higher than that of iron or steel; while the metal is at or near the welding heat and exposed to the air, a very rapid surface oxidization takes place, and the oxide or scale formed is extremely difficult to treat with any flux. The range of temperature between the heated plastic or welding condition and the fusing point of the material is very small. To add to the difficulties the metal becomes brittle as the temperature approaches the welding heat.

While aluminum reaches a welding heat at a temperature considerably below that of copper, it is also subject to a serious surface oxidization when exposed to the air at high temperatures. The range of temperature between the welding and fusing points of aluminum is only about 180 degrees F. If overheated it will simply spatter away under the hammer when attempt to make a weld is made.

The fundamental principle in the electric welding of metals is the same as in the forging operation, *viz.*, forcing the two welding surfaces into intimate contact while each is in a heated plastic condition. With the electric method the surfaces to be welded are butted together endwise instead of being "scarfed" and lapped. The repeated blows of a hammer are replaced by a mechanical pressure exerted in a direction forcing together the abutting ends of the work. The welding temperature is created by the heating effect of a current of large volume flowing through an electrical circuit in which nearly all the resistance is located at a single point. The abutting ends of the stock to be welded form this point of highest resistance in the electrical circuit of the welding machine, and practically all the heating effect is concentrated at this one point. A very rapid rise in temperature takes place until a welding heat has been reached. The electric current is simply the heating medium, and in itself has no effect upon the physical or chemical properties of the metal. The actual welding is due to the mechanical end pressure exerted while the material is in a plastic condition.

The electric butt-welding of wires, bars, rods, rings, etc., of the metals mentioned above requires a machine into which are incorporated the following essential parts in their proper relation to each other: 1. An alternating current transformer whose primary coils are made up of a large number of turns of insulated copper wire. The number of turns will depend upon the voltage of the supply circuit and the transformer secondary voltage required to make the weld. The size of the conductor will depend upon the kilowatt transformer capacity required to weld the largest stock the machine is designed to handle. The secondary winding of the transformer, on account of the very low voltage required, reduces to the equivalent of a single turn. This may be either in the form of a solid cast copper bar or a laminated copper structure whose cross-section is very large as compared to that of the primary conductors. The secondary voltage of the transformer will depend upon the cross-section and electrical conductivity of the stock at the point of the weld and varies from 1½ to 5 volts. The volume of current flowing in the primary and secondary conductors of the transformer will, of course, be in inverse ratio to the primary and secondary voltages. As an example, assume current at 220 volts primary voltage and that the current flowing in the primary coils of

* For additional information on the subject of electric welding, see the following articles previously published in MACHINERY: Some examples of Electric Welding, April, 1908; Electric Welding of Dissimilar Metals, July, 1908; Electric Welding of Tools, October, 1908; Electrical Welding, February, 1909.

† Electrical and Mechanical Engineer, The Toledo Electric Welder Co., Cincinnati, Ohio.

the transformer is 45.5 amperes. Assuming the secondary or welding voltage to be 2½, the secondary current will be (220 ÷ 2.5) × 45.5 amperes = 4,000 amperes, about.

2. A pair of copper dies or work holders in each of which is securely clamped one of the two pieces to be welded together. These dies serve to convey the secondary or heating current of the transformer through the stock to the point of weld, and are attached to the secondary terminals of the transformer in such a manner as to allow a small movement of the dies toward and away from each other. In practice one of the dies is fixed and the other movable.

3. A break-switch or circuit breaker mounted on the machine in a convenient operating position and so arranged as to be automatically opened and the primary current of the transformer broken at a certain predetermined point in the converging movement of the dies.

4. Arrangement for obtaining pressure. The pressure required to compress the stock while at the proper temperature and plasticity to make a weld is obtained by means of a compression lever, and a weight or springs acting upon the dies to force together the abutting ends of the pieces to be welded. This pressure follows up the compression of the stock to a point where it is no longer sufficient to displace the cooler metal, and the weld is made. The surplus heated metal is forced outward all around the stock in the form of a thin upset or fin which can, when necessary, be easily removed by grinding. The pressure required varies with the material and size of stock to be welded and must be adjusted to a point where compression takes place the instant the stock has reached the proper welding temperature. This adjustment, when once made, remains the same for all welds of the same material and cross-sectional area.

The time required to electrically weld copper, aluminum and copper alloys depends to a very great extent upon the cross-section of the stock, and varies from one second or less on very small stock to a minute or more on the larger sizes. The time limits between which stock of any given cross-section can be successfully welded are comparatively wide and governed in both directions by the volume of the heating current through the point of weld. If the current is low, the temperature rises more slowly at the point of the weld, and the heat travels back a considerable distance on each piece by conduction before the surfaces to be welded reach the required temperature. Under these conditions the fin or upset becomes quite large and entails too much expense in grinding to remove it. In the extreme case of insufficient current the heat is carried away from the point of the weld by conduction to the copper dies and by direct radiation to the air so rapidly that a welding temperature cannot be attained. If the volume of current is too great a very rapid heating of the stock takes place and trouble is experienced due to the fusing and oxidization at the point of weld which occurs more rapidly than the pressure can follow up the softening of the metal, and the excessively heated stock "spatters." Although the heating current is automatically cut off at the instant the forward motion of the die begins, the oxide coating on the end surfaces prevents a molecular union and a perfect weld. In other words, the stock is burned.

The heating current must be adjusted between the two extremes given above to a point where it is intense enough to bring the stock to a welding temperature, yet not so great as to cause an excessive heating and a "blowing out" of the weld. The correct adjustment is not a difficult matter, and is attained by varying the voltage impressed upon the primary coils of the transformer in one of two ways.

If the electric welder is operated by an alternator carrying this machine only, the voltage of the alternator (which in this case is the same as the primary voltage of the transformer) can be varied by a manipulation of the alternator rheostats.

When the electric welder is being operated from a circuit whose voltage must be maintained at a constant value, such as a power circuit from which other welders or motors are being operated, an inductive regulator is used as an auxiliary apparatus to the welding machine. The action of such a regulator is simply that of a variable choke coil, and any desired voltage can be obtained across the primary terminals of each welding transformer by a proper adjustment of the regulator.

A skilled or experienced man is not required for operating an electric welding machine as the only duties of the operator consist in clamping the work in the dies of the machine and closing the switch. For this reason it is customary to use boys on this work. Many machines for light work are now made automatic in their operation, requiring no attention beyond feeding in the stock to be welded.

Uniform and perfect molecular union is obtained with this process, since the heating of the stock is from within outward and the entire areas of the welding surfaces are at the same temperature. The strength of the weld is practically equivalent to the strength of any other section of the stock of equal area and will withstand any subsequent bending, rolling, hammering, or drawing process to which it may be subjected.

The difficulties encountered in the forging process due to the oxide surface films formed at high temperatures are not present in the electric process. During the extremely short heating period the welding surfaces are in contact and practically excluded from the air. Furthermore, the heating action ceases the instant the welding temperature has been reached, and the heat extends to but a very small distance on each side of the weld. It is obvious that with a continuously applied pressure which instantly compresses the stock to form a weld when the proper temperature has been reached, the difficulty experienced in other processes due to the small range of temperature from the plastic to the fused state of the metals is overcome.

The electric welding of copper, brass and aluminum is a very rapid operation and entirely free from noise, dirt and smoke. The machine can be located in any convenient position in the shop and is free from danger of electrical shocks to the operator. The motion of the movable die can be adjusted for both the forward and backward travel so that all welds are to gage. This is an important consideration when, for example, many thousands of rings must each be welded to an exact diameter.

The cost of electric welding is low as compared to other methods. Below is given a table for copper showing the kilowatts and time required to make a weld from the time of closing the switch. Also the cost per 1,000 welds at a unit basis of current cost of one cent per kilowatt-hour. To arrive at the actual cost of the current per 1,000 welds it is only necessary to multiply the cost given in the table by the price for current per kilowatt-hour in any given locality.

TIME, CURRENT CONSUMPTION AND UNIT PRICE FOR ELECTRIC WELDING OF COPPER

Area in sq. inch	Approx. Equiv. diameter, inch	Kilowatts	Time in Seconds to make Weld	Cost per 1000 Welds at 1 cent per K. W. hour Dollars
0.05	¼	5	4	0.055
0.10	5/16	7	5	0.097
0.20	7/16	14	7	0.272
0.30	9/16	19.5	9	0.487
0.40	11/16	26	12	0.866
0.50	13/16	32	14	1.240
0.75	1	46	17	2.170
1.00	1 1/8	62	21	3.610

* * *

It has been found during the Zeppelin aerial tours that it is difficult for the crew to determine the exact location when sailing over the earth in a dirigible balloon. It has, therefore, been proposed to place wireless signal stations in a number of leading cities and towns from which signals can be sent which would keep the aerial navigators constantly informed of their location. The sphere of influence of each station would be small enough so as not to interfere with that of the next. In this way it would be possible to always determine within certain limits the location of the airship. It is likely, however, that except for military purposes, such expensive arrangements to aid aerial navigators will not be necessary for some years to come. Should, however, some day aerial navigation become commercially possible, it is likely that wireless stations will act as the "light-houses" of the aerial sailor.

CASTING PIPE FITTINGS IN PERMANENT MOLDS

In the September, 1908, issue of MACHINERY, engineering edition, an article was published on "Casting Pipes in Permanent Molds," which described the methods in use at the Tacony Iron Co., Philadelphia, Pa. The molds used for the casting of pipes were made of cast iron, but the cores used were of the regular type, made of sand. Improvements have now been made with this process. The casting of fittings in permanent molds was experimented with, after success had followed the use of these molds in casting pipes, but sand cores were found

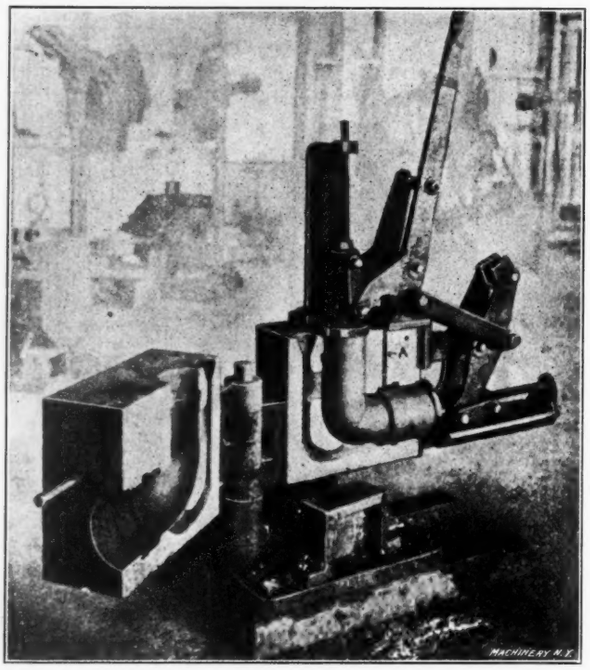


Fig. 1. Permanent Mold for 5-inch Quarter Bend showing the Cores in Position for Casting

impossible to use successfully, owing to their irregularity of form, and it was practically decided to discontinue further experiments along this line when, as a last resort, cast iron cores were suggested and tried. These experiments proved successful from the start.

This departure upsets one of the fundamental traditions in the art of founding, and may prove to have tremendous possibilities. In an article in a recent issue of *The Foundry*, the

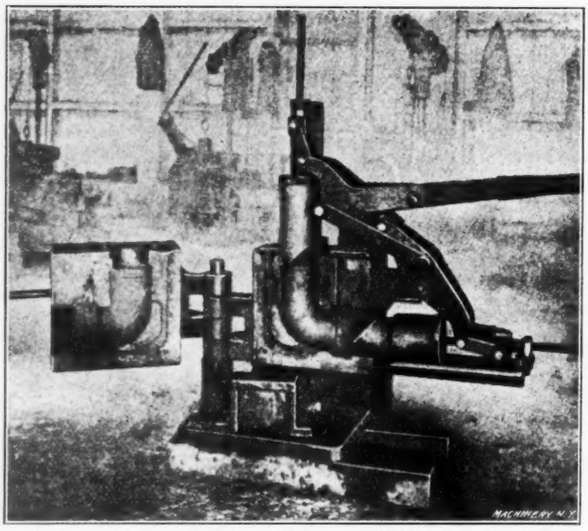


Fig. 2. Casting poured, Cores withdrawn and Mold opened, showing the Pipe Fitting

methods used are described in detail and the accompanying illustrations are reproduced from that description. It is stated that the castings made vary from 4 to 28 pounds in weight, and the average labor cost is approximately 2 cents per casting, as compared with an average molding cost of 6 cents when the fitting is cast in sand. In addition to the saving in labor cost the expense of sand and flasks is entirely eliminated, and while against this must be charged the cost of molds and the machines, this cost amounts to only a fraction of a cent per casting.

On an average each mold has an output of 1,000 pounds of castings daily. The output per day of small fittings is greater in number than that of the heavier fittings, because they can be cast more rapidly, as they do not heat the molds so quickly. If the molds are raised to a red heat they deteriorate more rapidly than when the temperature is not high enough to color them. The success of casting in permanent molds depends on a swift chilling of the molten iron to the point at which it is set, at which time it must be immediately removed from the chilling effect and permitted to cool normally. If the cast-iron cores are not removed immediately after the iron is set, the shrinkage of the iron holds the cores so that they cannot be withdrawn. However, even in such a case the mold can be opened and the casting broken with a hammer to release the cores, and the only loss incurred is the labor required in producing the casting, because the mold and core remain uninjured.

The permanent molds in the machines used for different classes of fittings and other castings are all similar in that half of the mold is fixed while the other half swings on a hinge. A machine for molding five-inch quarter bends is shown in Fig. 1. This illustration shows the mold open with the cores in position for casting. As soon as the two halves are closed up the metal may be poured. At *A* in the illustration is shown a vent which is provided to permit the air

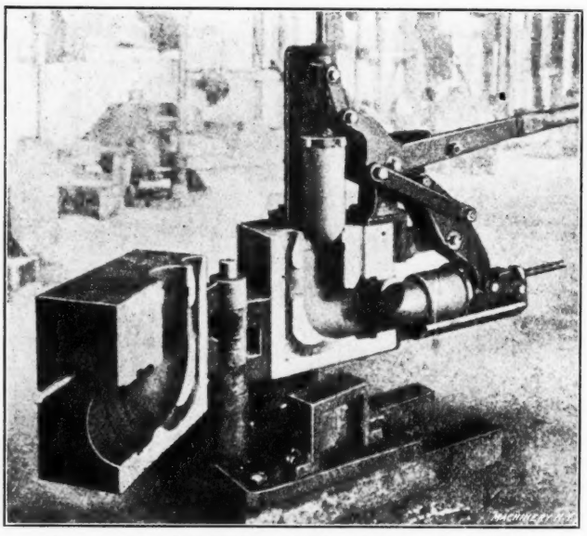


Fig. 3. Casting Removed from Mold; Cores not yet in Position for Next Casting

in the mold to escape. The cores are also drilled to permit the passage of air into the mold when the cores are removed.

In Fig. 2 the casting has just been poured and the two halves of the core have been withdrawn by depressing the operating lever. Immediately after the withdrawal of the cores the movable half of the permanent mold is swung out as shown in the illustration, permitting the removal of the casting. In Fig. 3 the casting has been removed, but the cores have not been replaced in position for casting. When this is done the appearance is as shown in Fig. 1, and the cycle of operations is repeated.

No especial care need be exercised to prevent the castings from sticking in the molds, but the mold, as well as the cores, is occasionally coated with a mixture of thin oil and graphite. The molds and the cores are cast from ordinary gray iron, such as is used for the soil pipe and fittings made, and in one mold more than 6,000 pieces have been cast without there being any signs of deterioration. Very small castings can be produced very rapidly. Plow points, for example, can be cast at the rate of four per minute, while larger fittings cannot be cast faster than one every two minutes, and in the case of pipe, it was found that but one casting could be made every eight minutes. Outside of cast-iron fittings, molds have been designed for brake shoes, sash weights and various kinds of hardware.

THE OPERATION AND CARE OF SMALL ELECTRICAL MACHINERY*

By HENRY B. BIXLER†

As the majority of users of small electrical machinery are not familiar with the best methods employed to keep the machines in good running order and repair, the author aims to give in this article a few practical suggestions, to be of some help in the making of necessary repairs, locating troubles, and removing the causes.

The dynamo or motor should be installed in a dry place, and under no circumstances should water be allowed to come in contact with the machine. Excessive dampness always causes trouble, and this point should be guarded against. The machine should be well ventilated, and kept free from dust as much as possible. Before starting a new machine, see that the bearings are well filled with good oil, and that the shaft turns freely in the bearings. The oil-rings should turn with

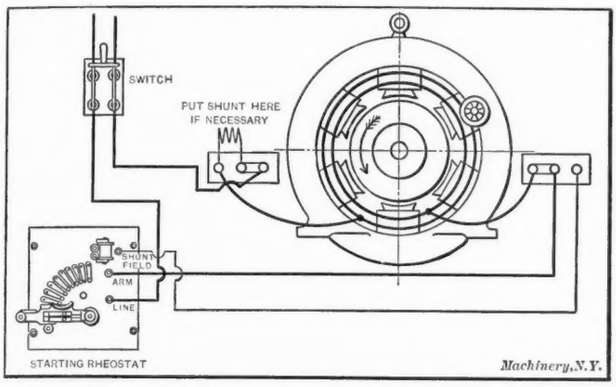


Fig. 1. Diagram showing Reduction of Over-load by means of a Shunt

the shaft, and not stick, as the lubrication of the bearings depends upon the rings working right. This is important and should be carefully watched. If the machine is belt driven, the belt should not be too tight, as this will cause undue wear on the bearing and may cause heating also. Always provide solid foundations or supports for the machine to rest on. Keep the machine cool, dry and clean, and very little trouble will result in its operation in general.

When a new machine is installed and wired up, the connections should be carefully checked over, to see whether they correspond with the diagram of connections sent with the machine.‡ If this is found to be correct, and the machine refuses to act properly, the cause of the trouble should at once be located and the difficulty removed before going further.

Troubles in the Field Coils

First we will consider the troubles that may exist in the field coils, and how to proceed to correct them. If, on running a machine for some time, the field coils all become hot, the voltage may be too high and should be reduced to normal. If only a part of the coils become hot, it will usually be found that a connection exists between the coils and the frame of the machine (called "ground"), which when found should be insulated with mica or paper. Sometimes it will be found that some of the coils are cold while the remainder are excessively hot, and the cause of this is a short-circuit in the cold coils, which means that the current is not passing through the coils. Test out the coils separately with a magneto or battery, and when the defective coil is found, it should be repaired by reinsulating it.

A partial short-circuit will cause the coils to heat, and should be treated as stated above. In a compound-wound machine, *i. e.*, one having a shunt and series winding on the field coils, an over-load will cause an excessive current to flow through the series coils, causing the heat to rise above normal. The load should be reduced or a "shunt" should be connected as shown in Fig. 1. This will cause the current to divide, part of it flowing through the shunt, thereby reducing the heating of the series coils.

If a machine is run as a generator and will not generate the rated voltage, that is, if it shows too low voltage, or if the speed is too high when run as a motor, the cause may be a loose field connection, which should be carefully traced and tightened. Any extra resistance in the field will cause a motor to speed up, and the rheostat, in case one is installed, should be cut out of the circuit. The same trouble will arise from a short-circuit in one or more coils, or having the polarity reversed in one or more coils. Test this with a compass, or reverse the leads of one coil. If a generator will not hold up the normal voltage when loaded, or if the speed of a motor is too high when running under full load, the series field is either cut out of circuit or is reversed and is opposing the shunt. Disconnect the shunt coils entirely and try the machine without them. If the operation is now satisfactory, reverse the leads of the shunt field, and again connect them. If the motor refuses to start, there is no current through the shunt field, and the open-circuit should be found and repaired.

In case the motor takes an excessive starting current, the series field is opposing the shunt, and one of them should be reversed. If the motor runs the wrong way, reverse the series field or reverse the shunt field, or, in a compound-wound machine, both the series and shunt field. Never open the field circuit when the motor is running, as this would cause the machine to speed up to such an extent that the armature is liable to burst from centrifugal force. The above covers nearly everything that is due to field trouble.

Armature Troubles

When an open circuit occurs in a coil, it is shown by the broken leads, or by sparking at one or more bars of the commutator. The leads should be re-soldered into the commutator bars, or the broken wires spliced, or a new coil put in. Hot coils are caused by short-circuits at the commutator or between the separate turns of the coil, in case the winding is made up of more than one turn of wire for each coil, or from the grounding of the coil to the shaft or armature core. The leads should be separated and insulated from each other, and if this cannot be done, a new coil should be put in. Sometimes there is a short-circuit between the bars through the mica segment, or on the mica ring itself, and if this is the case, a new segment or ring should be put in, and the commutator turned off smooth in a lathe.

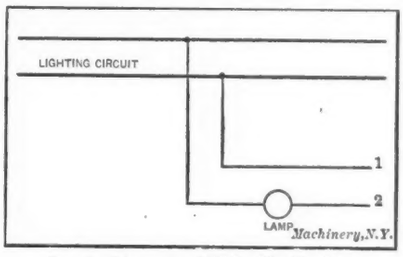


Fig. 2. Diagram of Wiring for Testing Armature Coils

When it is found that the whole armature heats up, the cause may be that the machine is pulling a greater load than it was originally designed for, in which case the load should be reduced, or else the machine exchanged for a larger one. If a machine is run at a lower rate of speed than that at which it is intended to operate, the armature often becomes quite hot, due to excessive iron losses, which will practically disappear when the speed is brought up to normal. The entire armature is sometimes heated by "cross-currents" which are set up in the windings due to the fact that the brushes are not set or spaced properly on the commutator. The only way to be sure that the brushes are spaced correctly is to count the commutator bars between each brush or set of brushes; this should be done as follows: Take for instance a commutator having 120 bars, and four sets of brushes. Set the first brush on any segment, and count thirty bars ahead of the bar on which the first brush is set, placing the next brush on this bar, and continuing thus around until all four brushes are placed in position. This will space the brushes equally apart, and when they are set properly, they can easily be kept in this position by making a gage of soft wire, just the length of the space between them.

* The following articles dealing with the care and repair of electrical machinery have previously been published in MACHINERY: Electric Repairing, December, 1904, January, 1905, and February, 1905; Winding of Direct Current Armatures, March, 1906; Tests for Faults in Armatures, May, 1906; Dynamo and Motor Troubles, September, 1906. See also MACHINERY'S Data Sheet No. 61 September, 1906: Diseases of Dynamos and Motors, and MACHINERY'S Reference Series No. 34, Care and Repair of Dynamos and Motors.

† Address: Hower Building, Akron, Ohio.

‡ Wiring diagrams for motors of various types, will be found in the Data Sheet Supplement accompanying this issue.

To fit the brushes properly to the commutator, set them in position as nearly as possible, and place a strip of coarse sand-paper around the commutator (sand side up) and turn the armature around slowly; finish with fine sand-paper, preferably No. 00. This, of course, refers to carbon brushes only, as hardly any other kinds are now used. After the brushes have been "sanded down," the spacing should be tested again, and the brushes re-sanded if necessary. Radial type brushes should present the entire end to the commutator, and should be thus fitted. After fitting the brushes, the carbon dust should be carefully blown off the machine before starting it up. Shift the brushes to the best running position, *i. e.*, where no sparking occurs at full load, and clamp the brush holder yoke in this position, marking it in some way so that it can be set again in this position if it becomes necessary at any time to move it. Sometimes the armature becomes hot from the heat given off from a hot bearing or commutator, and as this is a purely mechanical fault, it will not be discussed here.

Heating in many cases is caused by poor ventilation, and if this is found to be the trouble, the obstruction which prevents a free circulation of air around the machine should be removed, or if this cannot be done, a small fan can be used to give artificial ventilation to the machine.

Burned-out armatures owe their destruction to one or more of the following troubles: over-load, grounded line, grounded coils, short-circuit, either on the line or in the machine itself, cross-currents in the armature as mentioned above, or from lightning discharges coming in contact with the lines leading to or from the machine, or striking the machine directly, which however is a rare thing. The only remedy for a burned-out armature is to rewind it, or to replace the defective coils.

When a break-down of insulation occurs, a "ground" is the result, owing to the fact that a part or all of the current does not complete its circuit through the coil, but passes through the armature core and frame of the machine to the earth. If the bad place in the insulation cannot be found any other way, the leads should be removed from the commutator and tested out separately. If a lighting circuit is available, an effective test can be arranged as follows: Connect up a lamp as shown in Fig. 2 and place lead No. 1 on the shaft or other bright part of the machine; then touch lead No. 2 on each coil separately. If a coil is grounded, the lamp will light up, but will remain dark on the good coils. A bell and battery may be used with the same results, the bell ringing on the defective coils only. The grounded coils should be carefully insulated with mica or good tape, and the leads soldered into position.

Bearings are sometimes allowed to wear so much that the armature rubs on the lower pole-pieces, wearing the banding wires to such an extent that they break. The bearings should be renewed, and the armature re-banded, and centered up with the pole bore. Be sure there is plenty of good insulation under the band wires, and if this insulation comes out, as is often the case in old machines, it should be renewed, and new banding wires put on the armature.

Commutator Troubles

Excessive sparking at the brushes is one of the troubles most frequently met with, and one or more of the following reasons may be assigned to its cause. In nearly every case this trouble is caused by the brushes being out of position, and care should be taken to see that they are properly spaced as mentioned above. If, after the brushes are properly spaced, sparking still occurs, look for high bars in the commutator, for if one or more of the commutator bars stands out above the others, there will be a flash every time the high bar passes under a brush. The best way to remedy this is to remove the armature from the machine and turn off the commutator smoothly in a lathe, using a sharp V-pointed tool.

A high mica segment will also cause sparking, and should be brought down with a file. If the commutator is not too rough it can easily be smoothed with sand-paper, pressing this evenly against the surface while in motion. Better results are gained by raising the brushes from the commutator while sanding it off, and this can easily be done when the machine is running as a generator, but will not be so convenient in the case of a motor, unless some other source of power is available to rotate the armature. Never use emery paper for this work, as the dust may get between the windings of the armature and cause short circuits.

Sparking often results from excessive vibration of the machine, due to poor foundations, or to the armature itself being out of balance. If this is found to be the trouble, proper steps should be taken to remedy it. A weak motor field will often cause severe sparking, and the field connections should be made secure. Test the coils for short-circuits and grounds as shown in Fig. 2. When a weak field exists in a motor, it will always be noticed that the machine takes a great deal more starting current than when operating under normal conditions. Sometimes the brushes are not of the proper material; if so, they should be exchanged for others, softer carbon being used for lower voltages—110 volts, for example—and harder carbon for higher voltages—500 volts, for example. It has often been found that a change of brushes has entirely stopped excessive sparking when all other means had been resorted to and failed.

The brushes should have just enough pressure on the commutator to make good electrical contact; if the tension of the brush-holder springs is too weak, sparking will occur, as the brushes cannot follow the inequalities of the commutator, especially when it is a little rough. Too much pressure should not be given to the brushes, as this will cause the commutator to heat more or less, and will wear the brushes and commutator away a great deal faster than necessary. Oftentimes it is found that the brushes do not cover the proper number of commutator bars, and some of different thickness should be tried. If the brushes in use are too thin, they can be made to cover more bars by beveling them at a greater angle, by tilting the brush ahead and re-fitting it to the commutator.

When sparking occurs at only one or two points on the commutator, the trouble is usually due to a short-circuited or grounded coil, and a test should be made for this as shown in Fig. 2. When the defective coil is located, it should be securely insulated with mica or other suitable material. If the sparking is allowed to continue for any length of time, it may result in "pitting" the commutator so badly that it will be necessary to turn it off in a lathe before being fit for service again.

It is often found that several commutator bars become blackened after the machine has been in service for some time, the cause arising either from grounded or partially short-circuited armature coils, defective mica ring or segments, or from cross-current in the armature, set up by the brushes not being properly spaced. Directions have already been given for the repair of these troubles. Sudden or extreme fluctuations in voltage or sudden over-load will often cause severe flashing at the brushes. As this is due entirely to operating conditions, nothing further can be said than to eliminate these conditions as much as possible.

Troubles in the machine itself which cause flashing are poor brush contact on the commutator and wrong connections of the field windings in compound-wound machines. If the series field is connected in reverse to the shunt winding, flashing at the brushes is often the result. The series leads should be reversed, or if the trouble is due to the first-mentioned cause, the tension of the brush holder springs should be increased. If it is found that the commutator heats up above normal, it may be due to an over-load on the machine. If so, the load should be reduced or a larger machine substituted. Poor brushes, rough commutator or too much brush pressure always cause excessive heating, and should be cared for.

Never allow grease or dirt to accumulate on the brushes or commutator, and be sure that the brushes are having a good contact, and are pressing evenly against the commutator surface, fitting it perfectly at every point. After running a few days, the commutator should acquire a brownish glaze on the surface and nothing further need be done except to keep it clean by wiping it with a clean cloth every day or so. Very little lubrication is necessary, and none at all is a great deal better than too much.

The prime requisite for the successful operation of electrical machinery is cleanliness, and as stated in the beginning of the article, if the machine is kept cool, dry and clean, a great many of the troubles enumerated above will be greatly reduced, if not entirely eliminated.

TESTING MANGANESE STEEL SAFES

Pretty much all steel contains manganese. Ordinarily, it is to be regarded as an impurity giving brittleness to the mass. But back in the latter part of the nineteenth century it was discovered that, if the manganese content amounted to, say, 7½ per cent or something more, the resulting steel possessed in a high degree the valuable property of toughness. This is, it will be granted, rather a marvelous result. The ingredient which in a small percentage produces brittleness gives toughness when in fairly large proportion. The reason why this is so is not known, but the fact itself is well ascertained.

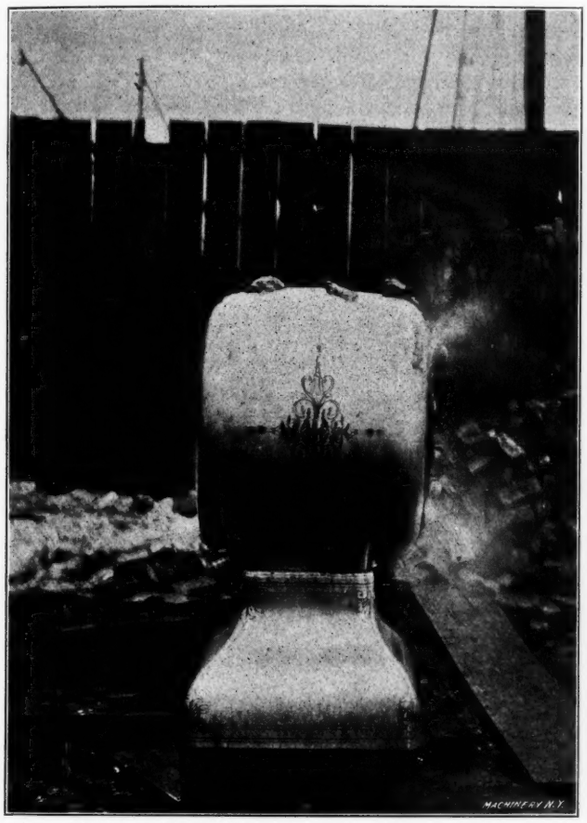


Fig. 1. Manganese Steel Safe tested by exploding Nitroglycerine in the Door Joint. Tenth Explosion—5 ounces Nitroglycerine

Some have supposed that manganese steel is very hard. It *is* hard but not excessively so. It is, no doubt, its toughness which has given it this reputation. The moderate hardness combined with the great toughness gives it such a refractory character that it is practically impossible to machine it. High carbon steel and high-speed steel are alike unable to conquer it. It is formed to shape by casting, forging, rolling and grinding. But this very character of high resistivity to tools has made it a very valuable material for burglar-proof safes. It is possible to remove the metal by a grinding wheel, and the writer lately saw a hole which had been made in the back of a manganese steel safe by grinding. But the wheel was power-driven, and it required more than a day and a half to produce its effect. It seems practically impossible, therefore, that a burglar should be able to force an entrance by means of cutting tools, whether of steel or emery. However, there is nitroglycerine. There is no material known having cohesive strength sufficient to resist this explosive. So we may expect that it will rend manganese steel, if it can be properly placed to render it effective.

Experiments along this line have lately been tried with interesting results. The manganese steel safe of the Ely-Norris Safe Co., 359 Broadway, New York City, consists essentially of two castings—the body and the door. The general form of the whole is that of a flattened orange. The door is a kind of stopper or bung fitting into its opening, with a ground joint. The inner end of the door and the corresponding part of the body are fitted with a system of interlocking lugs which are the real means of resistance to an effort to force the safe. There are bolts operated by the combination mechanism and the automatic device. But their office is mainly to prevent rotation and consequent release of the interlock of the lugs. The door, although it is a single casting, consists of a forward and rear part. These are joined by connecting lugs. There is thus left between the two parts an air space which is partly occupied by the combination mechanism. This space is the explosion chamber when subjected to attack. There are two spindles of manganese steel which occupy perforations in the forward plate. The fit is a ground one. The joint on the face of the safe between door and body is ground to make the two surfaces absolutely flush when the safe is locked. The obvious method of attack is by way of this joint or those about the spindles. In a test of a new $1,600 safe at the company's works at Perth Amboy, N. J., January 21, a point a little to the right of the uppermost part of the joint between door and body was selected as the point of attack. Without difficulty, an indentation was made by means of sledge and cold chisel. A "cup" of putty was placed in a suitable position, and one-half ounce of nitroglycerine discharged without apparently any decided effect. A second charge of one ounce was then discharged. The explosive seemed to have had but little effect. Applying sledge and cold chisel again, a third charge, consisting of one ounce, was exploded. It was fairly evident now that the joint was widening on each side of the wedge-like indentation of the chisel. Four more charges varying from one to two ounces were then used.

Fig. 2. Twelfth Explosion—at Night—7 ounces

Fig. 3. Condition of Safe after Nine Attacks in which Nitroglycerine was exploded within the Lock Chamber. Total Explosive used in these Nine Attacks 50 ounces

After the last or seventh discharge, it was evident that the nitroglycerine was penetrating to the explosion chamber. This was to be inferred from the fact that the front plate of the door was protruding slightly all around. Charges of three, four and five ounces were next exploded successively. The door was then observed to be protruding about 1/16 inch at the top, perhaps a little less at the right. At the bottom, the protrusion amounted to about 3/16 inch, on the left, about 5/32 inch. This displacement was to be attributed mainly, if not altogether, to a stretching of the connecting lugs, as the door itself was apparently intact. Four more charges of seven ounces each were next applied. The door was then found to be out an amount ranging from about 3/16 to about 1/2 inch. A final charge of eight ounces was then employed with no especial result.

It is to be observed that even had the outer plate of the door been forced off by stretching the lugs to the breaking point, the safe could not have been entered. There would still have been in the way a 5-inch plate or plug of manganese steel securely held in position by the interlocking lugs and the bolts of the automatic time mechanism. It does not seem apparent that a burglar would have had an advantageous opportunity for attack. No holes pierce this inner door. The only joint open to attack is the 5-inch ground taper contact between it and the body. The exterior plate may be regarded as merely the outer fortification—the main works are within.

These experiments show in a forcible way what a wonderful material manganese steel is. Hardened tool steel would probably have equal capability for resistance to machining, but this would hardly be accompanied by the great tenacity shown here. The question is how to shape it.

* * *

HARDENING SMALL BLANKING DIES

By H. J. BACHMANN*

It is manifestly an unprofitable investment to equip a manufacturing establishment with all the latest and most approved facilities for hardening, if there are only a few pieces to be treated occasionally. However, in cases of this kind, especially when blanking dies are to be hardened, it is up to the diemaker to make the best of the apparatus on hand. With this condition in mind, I will endeavor to set down specific directions which will invariably give definite and satisfactory results if followed closely.

If a blacksmith's forge is used, let the die be placed in the fire with the cutting face upward. During the period of heating, keep the fresh coal away from the die by surrounding it on all sides and on top with red hot cinder coal. When turning on the blast, be careful not to give it too much air. In fact, the more sparingly the blower is used, the better are the chances of the steel becoming evenly heated throughout. Even if the blast should be applied carelessly, the scaling and oxidizing will be more prominent on the bottom of the die where it is not so harmful. But most of all I wish to insist on an intelligent use of the blast. Turn it into the fire for about a minute, then shut it off and let the heat *soak* into the die insead of *blowing* it in. This is probably the most important point. The block of steel must be evenly saturated with heat and kept from contact with cold air until it reaches the proper hardening temperature. Remember to blow a little and then stop the air while the steel absorbs the heat. While the die is being heated, prepare a pail of clean water, taking the chill from it, that is, heating it until lukewarm. The die held in one hand with tongs, is then plunged into the water and kept moving all the time; when the die is cool enough, take hold of it with the other hand and stir the water with it until they both arrive at the same degree of heat. Now instead of taking the die out of the water and reheating it over the fire or letting it finish cooling in the air, just let the whole thing stand so that the water and steel will cool off together.

The entire method may be summed up as follows. Do not *shock* the steel by quickly heating it red hot or by plunging it suddenly into cold water. Let the change from cold steel to hot steel, and *vice versa*, be a gradual one; this will avoid all cracks and breaks due to any abrupt change in the molecular structure of the steel.

Address: 1234 Theriot Ave., New York

MACHINE SHOP PRACTICE*

TOOL GRINDING—1

In the grinding of tools, whether they are to be used for turning, planing or boring, there are three things of importance that need to be considered: First, the cutting edge of the tool (as viewed from the top) needs to be given a certain shape; second, there must be a sufficient amount of clearance; and third, tools, with certain exceptions, are ground with a backward slope or a side slope, or with a combination of these two slopes on that part against which the chip bears when the tool is in use.

In Fig. 1 a few of the different types of tools which are used in connection with lathe work are illustrated. This illustration also indicates the meaning of the various terms used in tool grinding. As shown, the clearance of a tool is the angular distance α; the back slope is represented by the angle β and the side slope by the angle γ. The angle δ for a tool without side slope is known as the lip angle or the angle of keenness. When, however, the tool has both back and side slopes, this lip angle would more properly be the angle between the flank f and the top of the tool, measured

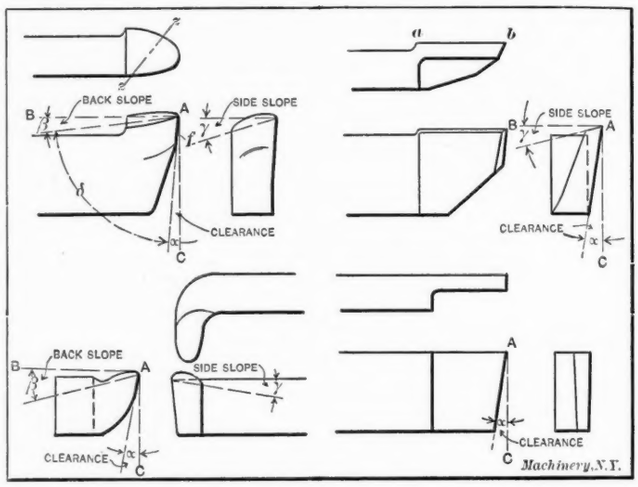


Fig. 1. Illustration showing the Meaning of Terms used in Tool Grinding, as applied to Tools of Different Types

diagonally along a line z—z. It will be seen that the lines A—B and A—C from which the angles of clearance and back slope are measured, are parallel with the top and sides of the tool shank, respectively. For lathe tools, however, these lines are not necessarily located in this way when the tool is in use, as the height of the tool point with relation to the work center determines the position of these lines so that the *effective* angles of back slope, clearance, and keenness are changed as the tool point is lowered or raised. The way the position of the tool affects these angles is illustrated on the Shop Operation Sheet accompanying this number.

Now, while tools must, of necessity, be varied considerably in shape to adapt them to various purposes, there are certain underlying principles governing their shape which apply generally; so in what follows we shall not attempt to explain in detail just what the form of each tool used in the machine shop should be, as it is more important to understand how the cutting action of the tool and its efficiency is affected when it is improperly ground. When the principle is understood, the grinding of tools of various types and shapes is comparatively easy.

In the first place we shall consider the shape or contour of the cutting edge of the tool as viewed from the top, and then take up the question of clearance and slope. Of course, when a tool is being ground it is given clearance and the required shape at the same time, but the different elements will be considered separately to avoid confusion.

The contour of the cutting edge depends primarily upon the purpose for which the tool is intended. For example, the tool *A*, in Fig. 2, where a plan view of a number of different lathe tools is shown, has a very different shape from that of, say, tool *D*, as the first tool is used for rough turning, while

* With Shop Operation Sheet Supplement.

tool *D* is intended for cutting grooves or severing a turned part. Similarly, tool *E* is V-shaped because it is used for cutting V-threads. Tools *A*, *B* and *C*, however, are regular turning tools, that is, they are all intended for turning plain cylindrical surfaces, but the contour of the cutting edges varies considerably, as shown. In this case it is the character of the work and of the cut that are the factors which determine the shape. To illustrate, tool *A* is of a shape suitable for rough turning large and rigid work, while tool *B* is adapted for smaller and more flexible parts. The first tool is well shaped for roughing because experiments have shown

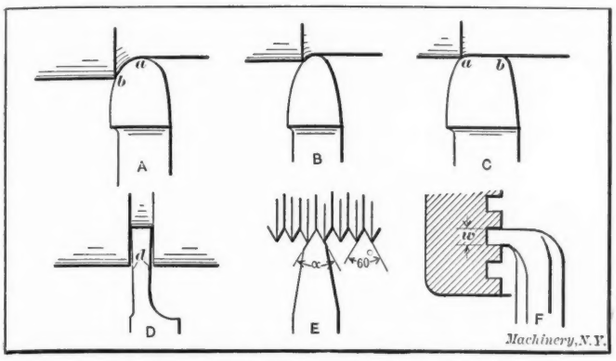


Fig. 2. Plan View of Lathe Turning and Threading Tools

that a cutting edge of a large radius is capable of higher cutting speed than could be used with a tool like *B*, which has a smaller point. This increase in the cutting speed is due to the fact that the tool *A* removes a thinner chip for a given feed than tool *B*. Therefore, the speed may be increased without injuring the cutting edge to the same extent. If, however, tool *A* were to be used for turning a long and flexible part, chattering would result. Consequently, a tool *B* having a point with a smaller radius would be preferable, if not absolutely necessary. The character of the work also affects the shape of finishing tools. The tool shown at *C* is used for taking light finishing cuts with a wide feed, and a tool similarly shaped is also used for the same purpose in connection with planer work. Obviously, if the straight or flat part of the cutting edge is in line with the travel of the

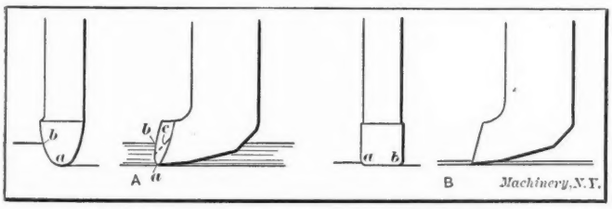


Fig. 3. Planer Tools for Roughing and Finishing Cuts

tool, the cut will be smooth and free from ridges, even though the feed is coarse. But such a tool cannot be used on work that is not rigid, as chattering would result. Therefore, a smaller cutting point and a reduced feed would have to be employed. Tools with broad flat cutting edges and coarse feeds are almost invariably used in taking finishing cuts in cast iron, as this metal offers less resistance to cutting than steel, and is less conducive to chattering.

The shape of a tool (as viewed from the top) which is intended for a more specific purpose than regular turning, can be largely determined by simply considering the tool under working conditions. This point may be illustrated by the parting tool *D* which, as previously stated, is used for cutting grooves, squaring corners, etc. Evidently this tool should be widest at the cutting edge; that is, the sides *d* should have a slight amount of clearance so that they will not bind as the tool is fed into a groove. As the tool at *E* is for cutting a V-thread, the angle α between its cutting edges must equal the angle between the sides of a V-thread, or 60 degrees. The tool illustrated at *F* is for cutting inside square threads. In this case the width *w* should be made equal to half the pitch of the thread, and the sides should be given a slight amount of side clearance, the same as with the parting tool *D*. So we see that the outline of the tool, as viewed from the top, must conform to and be governed by its use.

Aside from the question of the shape of the cutting edge as viewed from the top, there remains to be determined the amount of clearance that the tool shall have, and also the slope (and its direction) of the top of the tool. By the top is meant that surface against which the chip bears while it is being severed. It may be stated, in a general way, that the direction in which the top of the tool should slope should be away from what is to be the *working part* of the cutting edge. For example, the working edge of a roughing tool *A* (Fig. 2), which is used for heavy cuts, would be, practically speaking, between points *a* and *b*, or in other words, most of the work would be done by this part of the cutting edge; therefore the top should slope back from this part of the edge. Obviously, a tool ground in this way will have both a back and side slope. Similarly, the planer tool shown at *A* in Fig. 3, which is used for deep roughing cuts and does most of its work along the side between points *a* and *b*, should slope backward along a line *c*. When, however, most of the work is done on the point or nose of the tool, as for example, with the lathe finishing tool *C* (Fig. 2) or the planer finishing tool *B* (Fig. 3) which take light cuts, the slope should be back from the point or cutting edge *a*—*b*. As the side tool shown in Fig. 1 does its cutting along the edge *a*—*b*, the top is given a slope back from this edge as shown in the end view. This point should be kept in mind when grinding a tool, for when the top slopes in the right direction there is less resistance or power required for cutting. Of course, tools for certain classes of work, such as thread tools, or those for turning brass or chilled iron, are ground flat on top, that is, without either back or side slope.

The effect of too little or too much slope or clearance and some additional points of a general character on the grinding of tools, will be given in a succeeding installment.

* * *

ELECTRICAL INDUSTRIES IN GERMANY

In a paper read before the Institution of Electrical Engineers in Great Britain, the electrical industries in Germany were interestingly dealt with. The electrical manufacturing industry in Germany is at the present time almost entirely in the hands of four large companies. In the organization of these firms, we are told, an almost bureaucratic rule is in force. Each man's work is specialized in the minutest details, each branch of manufacture has an organization of its own with its own drafting-room, designing and clerical staff. Each type of motor is designed and manufactured in a separate department. Each firm has a special foreign department dealing exclusively with inquiries from abroad. All these departments are responsible only to a central authority or administration. The average technically educated employe is of high theoretical training, but salaries are kept low. As an example of the almost military rule, it may be mentioned that leave of absence of more than three days must be granted any employe by the central administration. The most striking feature of the shop system is the working day. It consists regularly of eighteen hours work in two shifts of nine hours each, with only a fifteen-minute interval during the nine hours, and half an hour between the two shifts. Thus the first shift works from 7 A. M. to 4.15 P. M., while the second works from 4.45 P. M. to 2 A. M. This system permits full advantage being taken of the machinery without working the men excessively long hours and without the necessity of paying over-time wages.

* * *

A rather peculiar safety device has recently been patented by Mr. Charles F. Pfalzgraf of Baltimore, Md., for preventing accidents to press operators. The device consists of an arrangement attached to the operator's arm, which, by means of electrical connections, makes it impossible to trip the treadle when the operator's hand is between the dies. When the device is properly adjusted, the arm must be moved back before the machine can be operated. With due esteem for all efforts that are made to prevent accidents in industrial work, it may, however, be doubted whether attachments arranged on the machine proper would not be preferable. To propose to connect up the operator directly to the machine seems like making him a part of it, even to a greater extent than he already is, and this may be neither expedient nor wise.

MILLING FIXTURES FOR AUTOMOBILE PARTS*

By E. H. PRATT†

The growth of the automobile industry has been so rapid that it has been found difficult for most factories to keep up with their orders. In order to avoid delays, a large number of companies have undertaken the manufacture of their cars complete. This necessitates the use of the most improved machinery, and also the designing and making of many special jigs and fixtures to insure the greatest possible amount of accurate work.

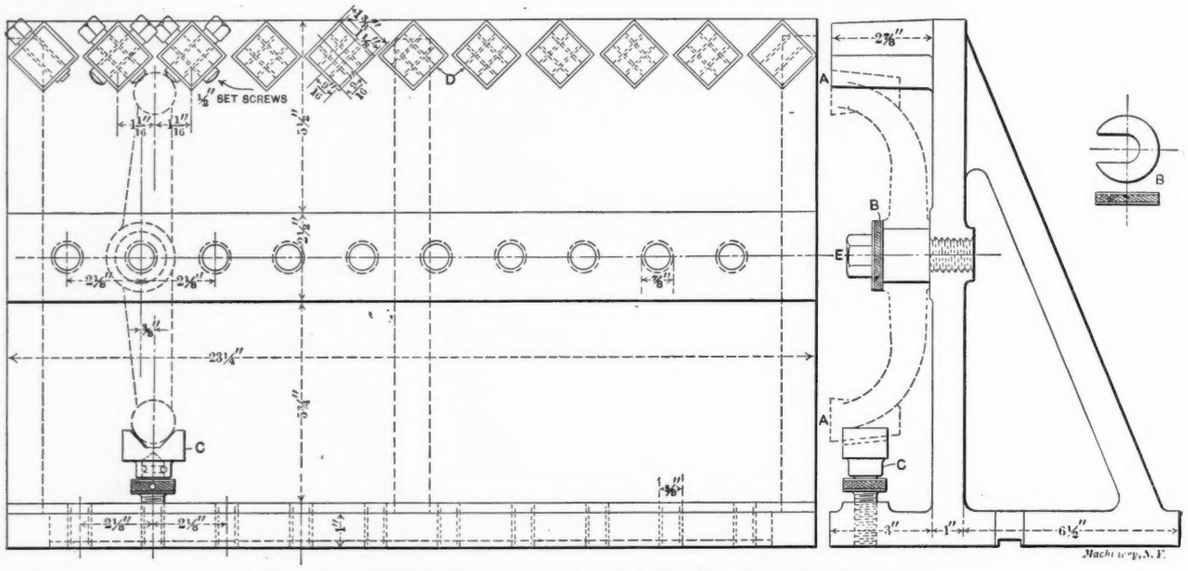


Fig. 1. Gang Milling Fixture for Castings shaped as indicated by the Dotted Outline

Among the most important fixtures are those used for the milling operations. There is a very close limit of variation allowed on most milling work, which in many cases is not more than one-half thousandth inch. This close margin is due to the introduction of the duplicate-parts system now used by the leading manufacturers. In most cases milling operations are the first ones performed; therefore the greatest difficulty is encountered in clamping the work in the fixture in such a way as to locate it properly from the uneven surface of the casting or forging without springing it.

Some of the fixtures and clamping devices used in one of the largest and best equipped automobile factories in the country, which were designed to overcome such difficulties are illustrated and described herewith. An efficient type of milling fixture for holding a number of light brass castings is shown in Fig. 1. These castings, as indicated by the dotted lines, were of a rather peculiar shape, having a heavy boss on each end and one in the center with light webs connecting them. It was necessary that the faces of the bosses *A* be milled at right angles with a hole through the central part of the casting. There was the usual difference in the shape and size of these bosses, that exists in all castings of this kind. Provision was made for machining ten at a time. The adjustable jacks *C* have swivel heads which seat themselves firmly to the uneven surfaces of the tapered end bosses. These jack heads are of machine steel and casehardened. The square bosses *D*, on one side of the fixture, each have two set-screws passing one above the other, at right angles. These screws take care of variations in the castings and securely hold the bosses in position. A hole in the center of each casting fits over a stud *E* which is provided with a slip washer *B* and a nut which aids in holding the casting securely; by using a large end mill the pieces are very quickly and accurately machined.

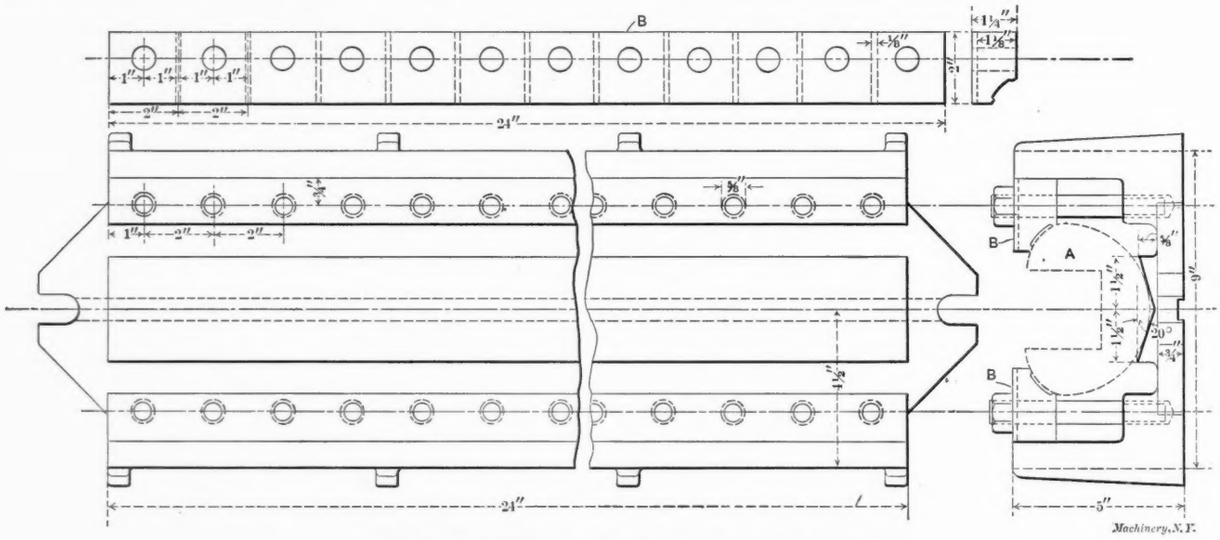


Fig. 2. Gang Milling Fixture for Engine Counterweights

A milling fixture for crankshaft counterweights and the method of clamping and locating the work in the fixture, is illustrated in Fig. 2. The counterweight *A* has circular sides and a large milled opening, as shown by the dotted lines. Twelve weights are placed in the fixture at once; these are securely held in position by one stud on either side of each counterweight, in conjunction with clamps *B*, which are machined to fit the curved surface of the counterweight. These clamps, one of which is illustrated at the top of the engraving, are machined in long strips and are sawed nearly through at

* For previous articles on this and similar subjects, see "Automobile Factory Practice" in the January, 1910, issue of MACHINERY, engineering edition, and articles there referred to.

† Address: 503 St. Joseph St., W., Lansing, Mich.

intervals equal to the width of the counterweight, thus allowing each section to act independently. The sides of the fixture are made very rigid to withstand the outward strain when clamping. The end view plainly shows the locating V in the bottom of the fixture, and also the studs and clamps in position on the counterweight. These counterweights are rough steel castings which makes it particularly difficult to keep them within the 0.0005 inch limit allowed in the milled groove. To get interlocking cutters of the dimension required, would take considerable time, therefore an inserted tooth cutter was made in which every alternate tooth projected ahead of the other on both sides. When the cutter becomes too narrow, it is easily adjusted by driving one tooth one way and the next one the other, and regrinding to size.

A design of spring-hanger for an automobile, and also the fixture for milling it, is illustrated in Fig. 5. This spring-hanger is a drop forging, and it is hollowed out to accommodate the width of the spring. It is not machined on the inside, but the ends *C* need to be faced. The hangers are located on the fixture by the lugs *A* over which they fit, as indicated by the dotted lines. The surfaces of these lugs are relieved, as shown, to ensure accuracy in locating by the unfinished surface of the forging. The groove *B* in the bottom of the fixture, is for a locating key which fits the T-slot in the milling machine table. The clamp *D*, used on this fixture, is of the type ordinarily employed on quick-acting milling devices. Both right and left hangers can be machined on this fixture, and by using a large straddle mill both faces are finished simultaneously. After the ends have been faced, the hangers are sent to the drill department and the hole *E* is drilled. They are then returned to the milling department for the second milling operation which consists in finishing the flat surface *G* (Fig. 4) that fits the inside of the frame. As this is a slow operation, the fixture was designed to hold as many hangers as could be placed within the feed limit of the milling machine table. This fixture is shown in Fig. 4 and the position of the work when set up in it is indicated by the dotted lines. The hangers are located by studs *A* that fit into the holes previously drilled, and also by the milled surface *B*. After the hangers are placed on these locating studs, they are clamped by means of the strip *C*. This strip is slotted at intervals as shown in the detail view and it is divided into as many sections as there are hangers to be clamped. As the set-screws *D* are tightened, each section acts as an independent vise jaw. The work is prevented from shifting or springing by the stop-pins *E* and the thrust-screws *F*.

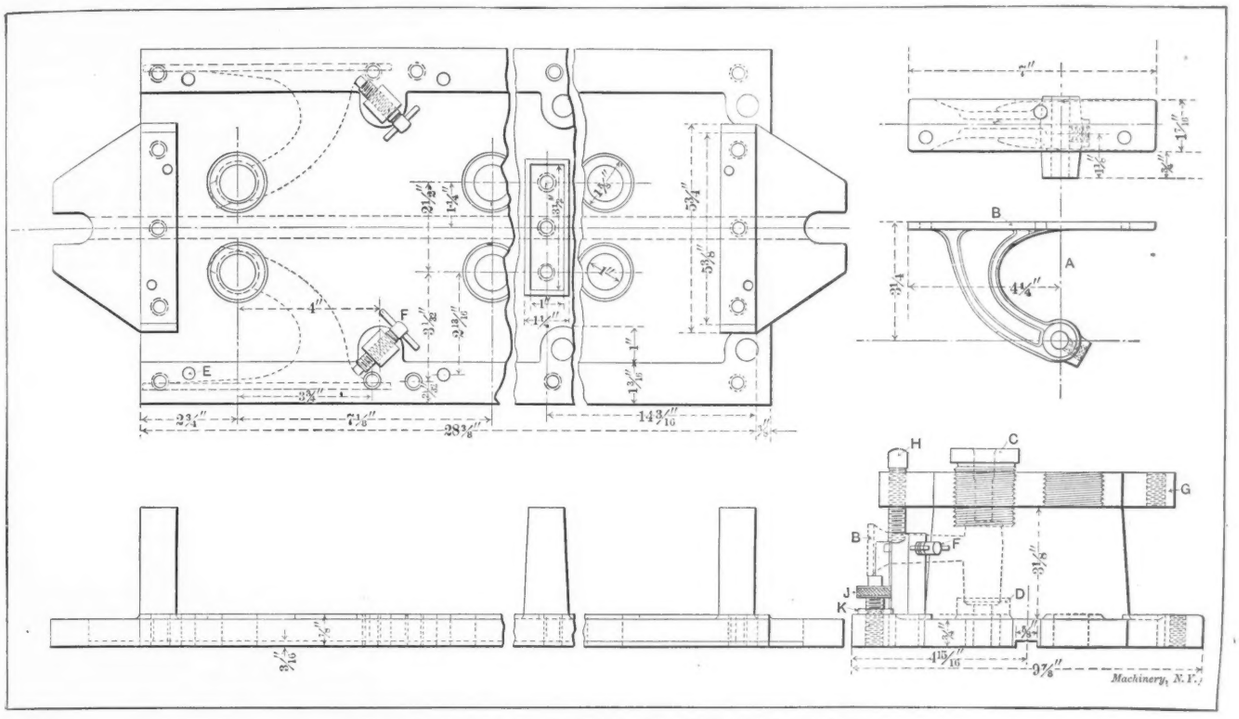


Fig. 3. Combination Milling and Drilling Fixture for Spring-hangers

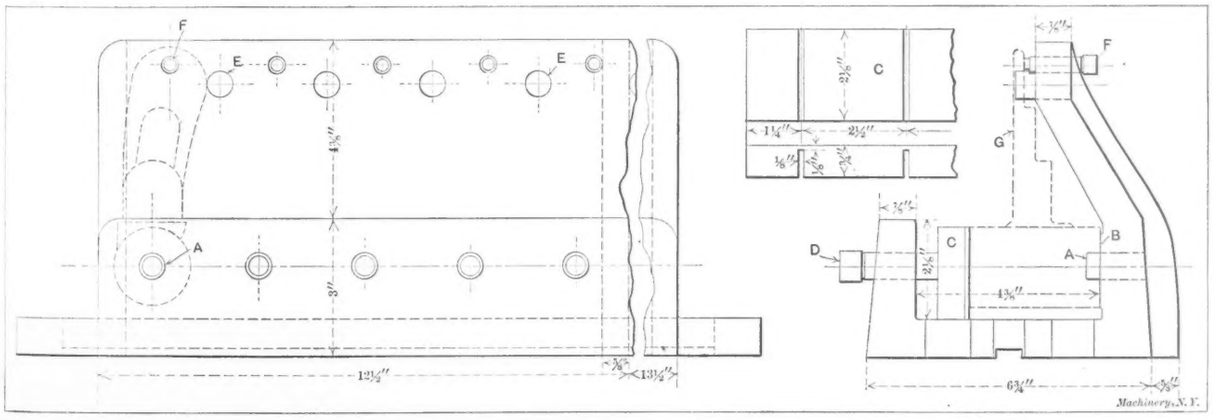


Fig. 4. Gang Fixture in which Surfaces G of Hangers are milled

The clamping device used on the combination milling and drilling fixture shown in Fig. 3 is in common use on drill jigs, but it is seldom used on milling fixtures. The work is located for milling by the same bosses that are used for the drilling operations. The peculiar shape of the spring-hanger forging for which this fixture is intended, is shown by the detail at *A*. This fixture is designed to mill the surfaces *B* of eight hangers at a time by using large straddle mills. Bush-

ings *C* and *D* locate the work by the hub ends as shown. The hangers are prevented from shifting by stationary stop-pins *E* against which they are forced by lock-screws *F*. The bushing plate *G* also contains clamping screws *H* which hold the hangers firmly on the adjustable studs *J*, of which two are used for each hanger. After these studs are adjusted to the work, they are held in place by lock-nuts *K*.

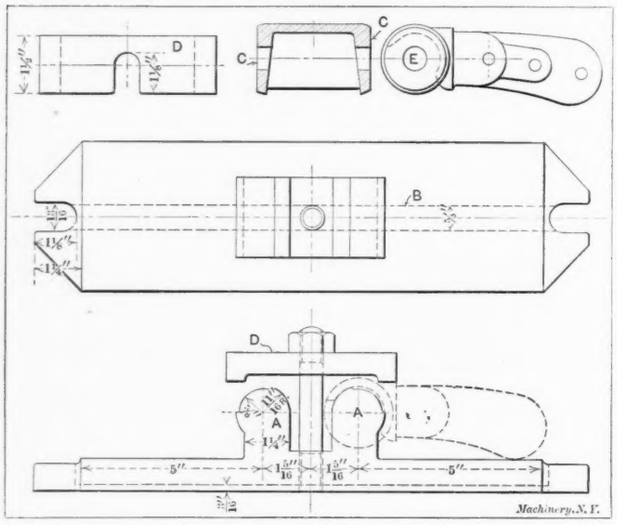


Fig. 5. Fixture for Milling Sides C of Spring-hanger

The bushings *C* and *D* are provided with holes of the same diameter as those to be drilled in the boss of the hanger, and when the fixture is not in use on the milling machine, it can be used on the multiple spindle drill press, thereby forming a combination milling and drilling fixture.

* * *

BALL POINT VERSUS ANVIL TYPE THREAD MICROMETERS

Two forms of measuring points are employed in practice for comparing the pitch diameters of threaded work. The first and oldest of these, shown in Fig. 1, is the method employed on the Brown & Sharpe thread micrometer. This may be used for positive measurements, as well as for comparisons. Figs. 2 and 3 illustrate another principle of measuring, using in the one case a ball point micrometer and in the other case wires of suitable diameter measured with the regular micrometer caliper. The arrangement shown in Figs. 1 and 3 may be used for other positive measurements or comparisons with other threads. The device shown in Fig. 2, owing to the tilting of the micrometer required, should be used for comparative measurements only between two threads of supposedly the same exact form.

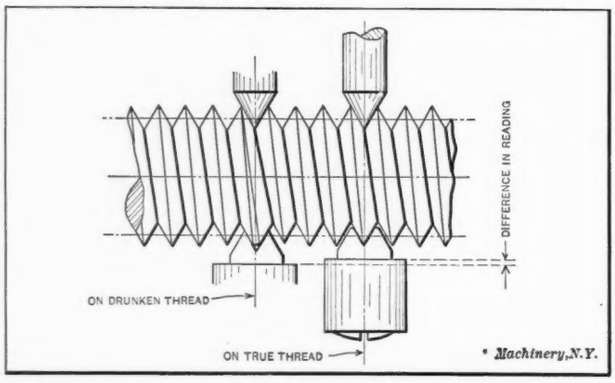


Fig. 1. The Anvil Type of Thread Micrometer gives Varying Measurements on True and Drunken Threads

A recent experience of a well-known machine tool building firm shows, however, that the scheme of Fig. 2 cannot be relied on in certain cases, even for comparative measurements, and the same holds true of Fig. 3. The way in which this was discovered brings up a very interesting point in machine tool construction as well as in thread measuring.

This manufacturer bought a lathe for cutting accurate threads. It was provided with a lead-screw which proved to be satisfactory from the standpoint of the accuracy with which it was cut. A serious error developed, however, in its mounting in the machine. It was provided with a loose thrust collar between the shoulder of the lead-screw and the face of the bearing bracket which took the thrust in feeding the carriage. This thrust collar unfortunately was very poorly squared up, being some thousandths thicker on one side than on the other. Unfortunately again, the thrust surfaces on the lead-screw and the bearing, between which it was placed, were also poorly faced, running out sidewise to an appreciable extent. As a result of this combination of misfortunes the lead-screw, in revolving, received an irregular endwise movement resulting from the varying position of the untrue loose washer between its untrue thrust surfaces. The machine thus cut an irregular drunken thread.

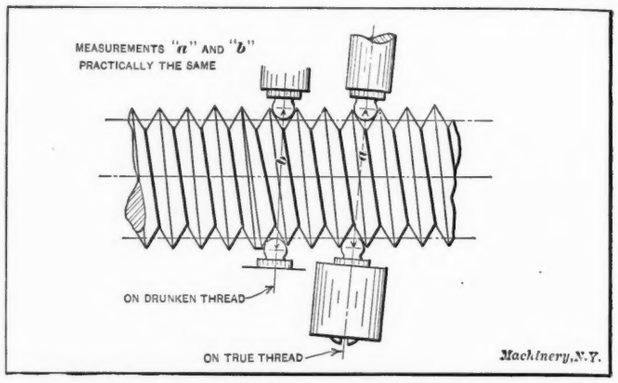


Fig. 2. The Only Difference in Measurement made by the Ball Point Micrometer is due to the very Slight Difference in Inclination—too Slight to be Appreciable

This fact was brought to the attention of the makers of the machine, who measured with the ball point micrometers a sample screw cut by it, and pronounced it O. K. The purchaser of the machine, however, brought out a measuring tool of the type shown in Fig. 1, and this at once indicated varying diameters in different parts of the thread, giving evidence of the irregularities of which he complained.

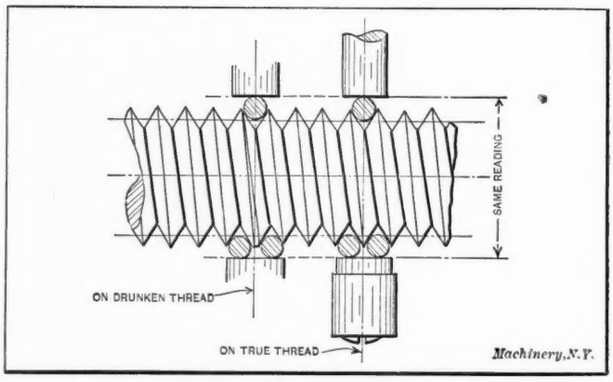


Fig. 3. The Three-wire Method of Thread Measurement makes no Distinction between True and Drunken Threads

The reason for this is evident. The ball point micrometer measures the groove cut by the thread tool, and as this is always set at the same depth and is unvarying in shape, the error was undetected. The same conditions are met with in the three-wire method, shown in Fig. 3. The lower anvil point in Fig. 1, however, since it spans the abnormal thread, instead of making contact with the sides of adjacent threads, indicates the irregularity by giving an increased reading for the pitch diameter.

This point of the accurate squaring of the thrust surfaces for precision lead-screws is a very important one; and it is one that it liable to be neglected by those who have given no thought to the matter. We have been told by a man of wide experience in accurate thread cutting, that it is fully as difficult and of fully as great importance to mount a lead-screw properly in the lathe for use, as it is to cut it accurately in the first place.

FORMULA FOR THE VOLUME OF A PART OF A SPHERICAL SEGMENT

In the December, 1908, issue a request was submitted by F. M. S. to the readers of MACHINERY for a formula for the volume of a section of a spherical segment. In the accompanying illustration the heavy lines show half of the part of the segment, the volume of which is required. The method for finding a formula for this volume involves a vast amount of mathematical work, and it is not possible to give space to the derivation, which would occupy more than four full pages in MACHINERY. The formula for the volume, however, is:

$$V = \frac{2SP\sqrt{C^2-P^2}}{3} + \frac{\pi(SC^2-4Sr^2+4r^3)}{6} - \frac{3r^2P-P^3}{3}$$

$$\sin^{-1}\sqrt{\frac{C^2-P^2}{r^2-P^2}} - \frac{S(C^2-4r^2)}{3}\tan^{-1}\sqrt{\frac{C+P}{C-P}} -$$

$$\frac{2r^3}{3}\left(\tan^{-1}\sqrt{\frac{(C+P)(r+C)}{(C-P)(r-C)}} + \right.$$

$$\left.\tan^{-1}\sqrt{\frac{(C+P)(r-C)}{(C-P)(r+C)}}\right) - \frac{SC^2}{2}\sin^{-1}\frac{\sqrt{C^2-P^2}}{C}$$

in which V = the volume of the part of the spherical segment

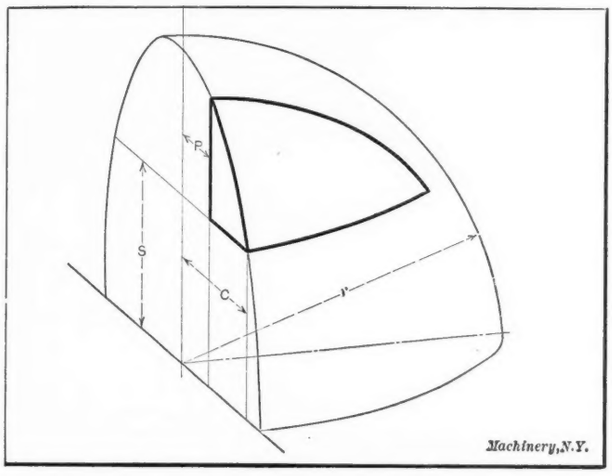


Diagram showing Notation for Formula for the Volume of a Part of a Spherical Segment

required, which is twice the volume of the section shown with heavy lines in the accompanying illustration, and S, P, C and r are dimensions as given in the illustration, r being, of course, the radius of the sphere. This formula with its derivation has been worked out by Mr. R. A. Jewett, of 35 Pinkney St., Boston, Mass., and he does not think that the formula can be simplified further. F. M. S. asked for the volume in terms of the radius of the sphere, the height of the segment, and the distance between the central plane and the plane passed through the segment, this latter distance being shown as P in the illustration. Of course, these values for the height of the segment could be substituted in the formula, but to do so would vastly complicate what is already too complicated, and the result would be an unwieldy, if not an unmanageable expression.

The formula has been checked by actual figures and been found to work out exactly. The method for checking is to assume some limiting value for certain dimensions, so that the volume can also be calculated by any of the general formulas for spherical segments. In this way, if the two values obtained by the two different formulas prove to be equal, the formula here given can be relied upon to be correct. We are reasonably sure, however, that no one will use this formula except in a case of dire necessity.

SPECIAL UNIVERSAL VISE FOR GANG PLANING

By E. H. WEISS*

When it becomes necessary to machine small, slender pieces in quantity, whether the forms are complicated or not, it is usual to use a formed cutter for milling them, the cost of which is defrayed by the economy which results from the use of such a cutter as compared with hand work. If the number of pieces is comparatively small, it is best to plane them in a gang, while they are held in the vise, by the use of a formed planer tool. This operation consists in placing a number of

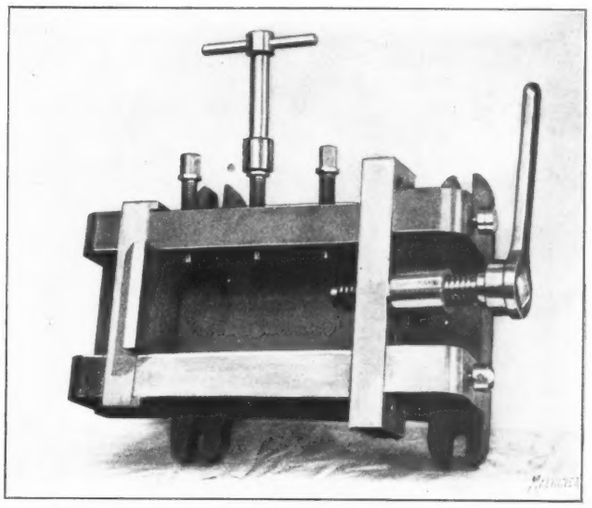


Fig. 1. Special Vise for Holding a Small Number of Duplicate Pieces on the Planer

pieces in a vise and shaping them all simultaneously. When the parts are machined by this method, it is necessary to strongly clamp them against each other, and when they are very small, it is often quite difficult to place the blocking so that it will not hinder the passage of the tool. I make use of a special chuck for this work which is of simple construction, as may be seen by referring to the accompanying illustrations, Figs. 1 and 2.

This chuck is composed of a base A of channel section, whose sides B are provided with slots in which are placed two steel rectangular cross-pieces C and D. The cross-piece D, carries a screw having a squared head which fits a wrench as shown in Fig. 1. This screw tightens the pieces together by bearing on a pad or block similar to E. It is possible to

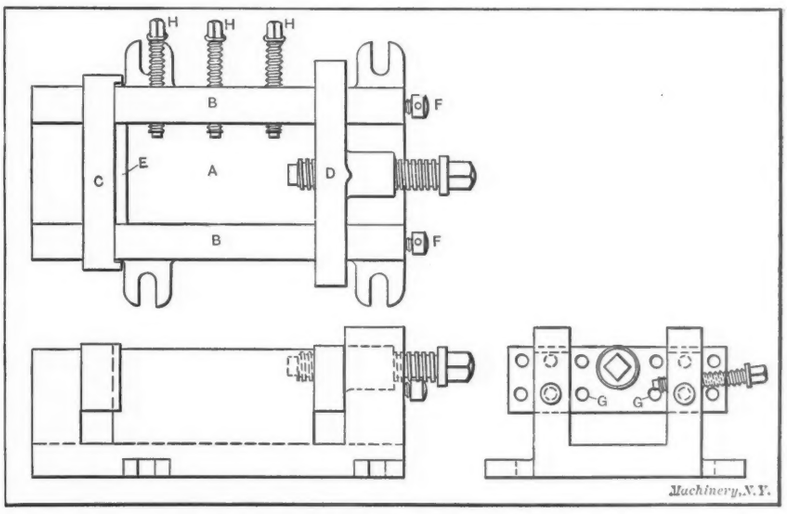


Fig. 2. Elevations and Plan of the Special Planer Vise

adjust the height of cross-piece D to agree with the height of the work, after which it may be locked in place by screws F, which fit into holes G. The location of the tightening screw can, therefore, be adjusted to any desired point on the work. To locate the row of pieces laterally, there are provided three

* Address: 2 Rue des Entrepreneurs, Paris, France.

screws *H*, in the side of the vise, which bear against a block similar to that shown at *E*. These screws are at a slight angle with the base of the vise, as shown, so that the pieces, when clamped, are forced into contact with the base or with such blocking as may be necessary to mount them on. The four slotted feet shown permit the vise to be securely clamped to the table of the machine by means of four bolts.

* * *

THE GROWTH OF CAST IRON

In an interesting paper entitled "The Growth of Cast Irons after repeated Heatings," read before the Iron and Steel Institute of Great Britain, September, 1909, the authors, Prof. H. F. Rugan and Prof. H. C. H. Carpenter, report the results of their investigations relating to the "growth" of cast iron.

The fact that certain types of cast iron grow after repeated heatings has long been familiar to engineers. Cast iron annealing ovens 8 feet in length, 3 feet in diameter, and 1½ inch in thickness, which are kept red hot for prolonged periods, between which they are permitted to cool off, sometimes grow to 9 feet in length in the course of their use. Cast iron furnace grates, range fittings, etc., subjected to alternate heating and cooling are also frequently distorted and sometimes broken from the same cause. It has been demonstrated that mild steel subjected to the same treatment does not grow, so that this quality is one peculiar to cast iron.

The principal investigator of the subject of the growth of cast iron after repeated heatings was, previous to the investigations of the authors of the paper referred to above, Mr. A. E. Outerbridge, Jr., of Philadelphia. His experiments were reported in the transactions of the American Institute of Mining Engineers, 1905, Vol. XXXV. In these experiments a cast iron bar of 1 by 1-inch section, 14 13/16 inches in length, was heated 27 times to about 1470 degrees F. for one hour. During this treatment it increased in size to 16½ inches length and 1⅛ x 1⅛-inch cross-section. This corresponds to an expansion of nearly 41 per cent. The enlarged bar had, it was stated, the same weight as the bar before the treatment. Twelve additional heatings increased the dimensions of the bar until the total expansion was 46 per cent.

The experiments of Messrs. Rugan and Carpenter were more extensive than those carried out by Mr. Outerbridge, but in the main, there is a close agreement in results. The following is a summary of the results of these investigators' experiments. The maximum growth of commercial cast iron takes place when the heating is continued for four hours at a time at a temperature of 1650 degrees F. In order that growth shall take place, both heating and cooling are required. The growths of the cast iron investigated varied between 35.2 and 37.5 per cent. It is interesting to note that the latter experimenters found that an increase in weight took place amounting to from 7.8 to 8.6 per cent. It is thus evident that the metal took up gases from the outside air, there being an oxidation of silicon and an oxidation of carbon. The ends of a cast iron bar grew more rapidly than the middle parts, which is readily explained by the fact that they expose more surface to the penetrating gases. The investigators, therefore, came to the conclusion that the influence of gases on the growth of cast iron is very important, and one test piece which grew very decidedly in a muffle furnace not only did not grow when heated in a vacuum, but it actually contracted 0.04 per cent. This would partly explain why Mr. Outerbridge's experiments did not show an increase in weight, as he enclosed his samples in an iron pipe closed at the ends with clay in order to prevent scaling; consequently there were practically no gases to be absorbed by the heated iron. On the other hand, this does not seem to explain satisfactorily the fact that his samples increased in size nevertheless.

In constructions where the growth of cast iron is objectionable, white irons should be used instead of gray; the most suitable composition appears to be an iron with about three per cent of carbon that has as few impurities as possible. As to the impurities, silicon is the most objectionable and it should not exceed 0.2 to 0.3 per cent. The only objection to using white iron for such purposes as annealing ovens, etc., would be that it might crack when heated, but this difficulty might be obviated by modifying the design.

MOMENT OF INERTIA OF BUILT-UP SECTIONS

By JAMES A. BROWN*

The usual method of calculating the moment of inertia of a built-up section involves the calculations of the moment of inertia for each element of the section about its own neutral axis, and the transferring of this moment of inertia to the previously found neutral axis of the whole built-up section. A much simpler method which can be used in the case of any section which can be divided into rectangular elements bounded by lines parallel and perpendicular to the neutral axis, is the so-called tabular method based upon the formula:

$$I = \frac{b\,(h_1^3 - h^3)}{3}$$

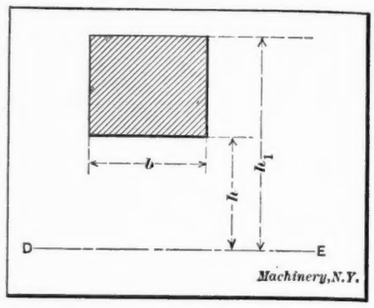


Fig. 1

in which I = the moment of inertia about axis *DE*, Fig. 1, and b, h and h_1 are dimensions as given in the same illustration. This method is given in Alexander and Thompson's "Elementary Applied Mechanics."

The method may be illustrated by applying it to the section shown in an article in the January issue of MACHINERY, entitled "To Calculate the Deflection of a Special Steel Section." This section is reproduced in Fig. 2, and for simplicity of calculation shown "massed" in Fig. 3. The calculation may then be tabulated as shown in the accompanying table. The distance from the axis *DE* to the neutral axis *xx* (which will be designated as *d*) is found by dividing the sum of the geometrical moments by the area. The moment of inertia about the neutral axis is then found in the usual way by subtracting the area multiplied by d^2 from the moment of inertia about the axis *DE*. The slight differences in the results from those given in the article in the January issue previously referred to are due to the use of a 5-inch slide rule in the present calculations.

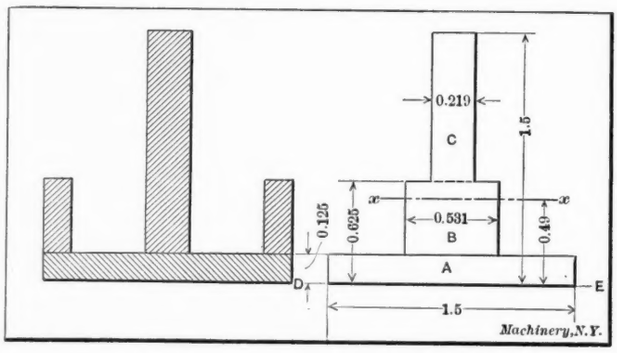


Fig. 2 Fig. 3

TABULATED CALCULATION OF MOMENT OF INERTIA

Section	Breadth b	Height h	Area $b(h_1-h)$	h^2	Moment $\frac{b(h_1^2-h^2)}{2}$	h^3	I about axis DE $\frac{b(h_1^3-h^3)}{3}$
A	1.500	0.125	0.187	0.016	0.012	0.002	0.001
B	0.531	0.625	0.266	0.391	0.100	0.244	0.043
C	0.219	1.500	0.191	2.250	0.203	3.375	0.228
			$A = 0.644$		$M = 0.315$		$I_{DE} = 0.272$

Distance d from DE to $xx = \frac{M}{A} = \frac{0.315}{0.644} = 0.49$.

Moment of inertia of whole section with reference to its neutral axis:

$$I_n = I_{DE} - Ad^2 = 0.272 - 0.644 \times 0.49^2 = 0.117.$$

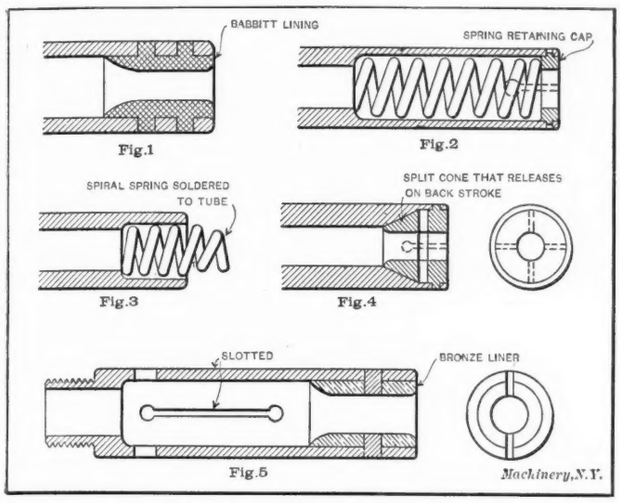
* Address: Holmesburg, Philadelphia, Pa.

LETTERS ON PRACTICAL SUBJECTS

Articles contributed to MACHINERY with the expectation of payment must be submitted exclusively

EXPERIMENTS WITH AUTOMATIC SCREW MACHINE FEED-FINGERS

When reading my November MACHINERY I was most interested in the "Dont's for Screw Machine Operators" by Mr. Paul W. Abbott, and the one that attracted my attention the most was "Don't let the first few pieces go by without looking to see if the feed-finger is scratching the work." Now I wonder if the writers of "Dont's" ever realize what it means to attempt to follow out their suggestions and then not altogether succeed in attaining the object in view.



Figs. 1 to 5. Various Types of Feed-fingers designed to prevent Scratching the Stock

The superintendent of a large factory once decided on the particular don't mentioned. He argued that to get closely-rolled bright stock and then mark or scratch it on the unturned parts was foolishness, so we had to get busy. To begin with, there was no thought of discarding the feed-finger and feed-tube for any other manner of feeding, as this method has many decided advantages peculiar to itself, not the least being that there is always a full chuck length of material left in the chuck when the feed-finger has parted with the last part of the bar, and there is also a minimum length of scrap.

When various makers were approached, they could suggest nothing that did not decrease the machine's capacity, such as making a 1-inch machine into a ¾-inch machine, etc., and

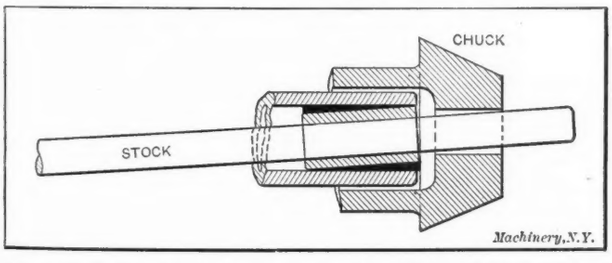


Fig. 6 Illustration showing on an Exaggerated Scale the Relative Positions of Stock and Chuck when Feed-finger Bushings are out of Line

indeed, the lack of space often cripples many of the devices which one immediately thinks of for this special operation.

We tried hardening and lapping the fingers and nicely rounding the backs of them, but while the results were better, they were far from satisfactory. The tinning of the fingers was then tried but this method was also unsatisfactory. Babbitted fingers, such as shown in Fig. 1, were then used, but these were constantly being enlarged by the new bars and relining was frequent.

Fingers such as shown in Figs. 2 and 3 were next tried, but the faults were numerous and the up-keep large, so these designs were also discarded. The design of Fig. 4 was then made and while it proved to be a useful type of finger, it had the disadvantage that when feeding up to a stop with a slight overfeed, it locked itself and caused the heating of the feed-tube; where it can be applied, however, for open feeding, it is very useful.

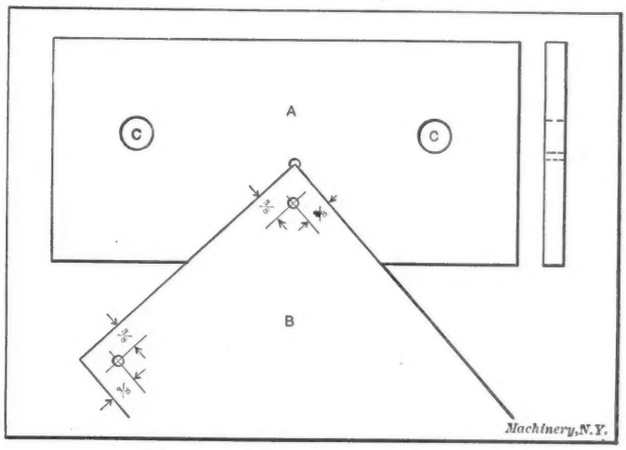
Solid bronze fingers were tried but these were rejected on the score of expense and also because they have little spring tension. Bronze bushings were next used and they, if anything, proved the best, but they left a lot to contend with. These fingers were made as shown in Fig. 5. The bushing was soldered in solid and then pinned in position so that introducing new bars would not knock it out. When the bushing was soldered in position it was placed in a little fixture and drilled to a suitable size; it was found necessary to do this as the bushings were sometimes placed in the tubes out of line, consequently the bar was fed forward out of line with the machine, as illustrated on an exaggerated scale in Fig. 6, thus putting extra work on the chuck and quickly undermining its accuracy.

As can be seen, this Don't caused considerable trouble and I should like to know if anyone else has had any particular experience with this special Don't. No doubt Mr. Abbott has some ready means of overcoming this trouble, inasmuch as he makes special reference to it in his interesting article.

J. S.

PLATE LOCATING FIXTURE FOR DRILL PRESS

A useful fixture for the drill press, that is used for locating steel plates, etc., that are to be drilled, is illustrated by the accompanying sketch. This fixture does away with the operation



Fixture for Locating Plates on the Drill Press

of laying out each hole preparatory to drilling. If a number of plates are to be drilled in the manner illustrated, the corner of one plate is first laid out and the hole drilled; the drill is not removed from the hole until the fixture *A*, which has been previously notched as shown, is brought against the plate *B* and is fastened to the table of the drill press by two bolts which pass through the holes *C*. The fixture is then ready for use, and it will locate the plates for the rest of the holes by simply inserting them in the locating notch.

I do not claim that this fixture will enable all the holes to be drilled with extreme accuracy as to distance, etc.; it is, however, a useful and time-saving fixture that I have often seen used with good results upon many ordinary jobs for which extreme accuracy was not essential.

C. F. EMERSON

DIAGRAM FOR GOTHIC LETTERS AND FIGURES

A diagram giving the proportions of Gothic letters and figures, is shown in the accompanying engraving. The system is so simple that the diagram is self-explanatory. By its aid Gothic letters and figures of any size may be rapidly drawn by means of ordinary instruments. In some cases,

appearance has been sacrificed to ease of construction, but the dominant consideration throughout has been absolute legibility. Many such systems of lettering have been prepared, some of which possess considerable artistic elegance, but none state with clearness the actual dimensions employed and, consequently, the construction of the letters is difficult. It was, therefore, decided to evolve a perfectly definite system of proportions. This system has been used for 5/16-inch letters on a drawing requiring unusual care, and also for painters' stencils fifty inches high. In both these extreme cases, and for many intermediate cases, the system has been found satisfactory to all concerned.

CARINGTON C. CARISS

London, Ontario.

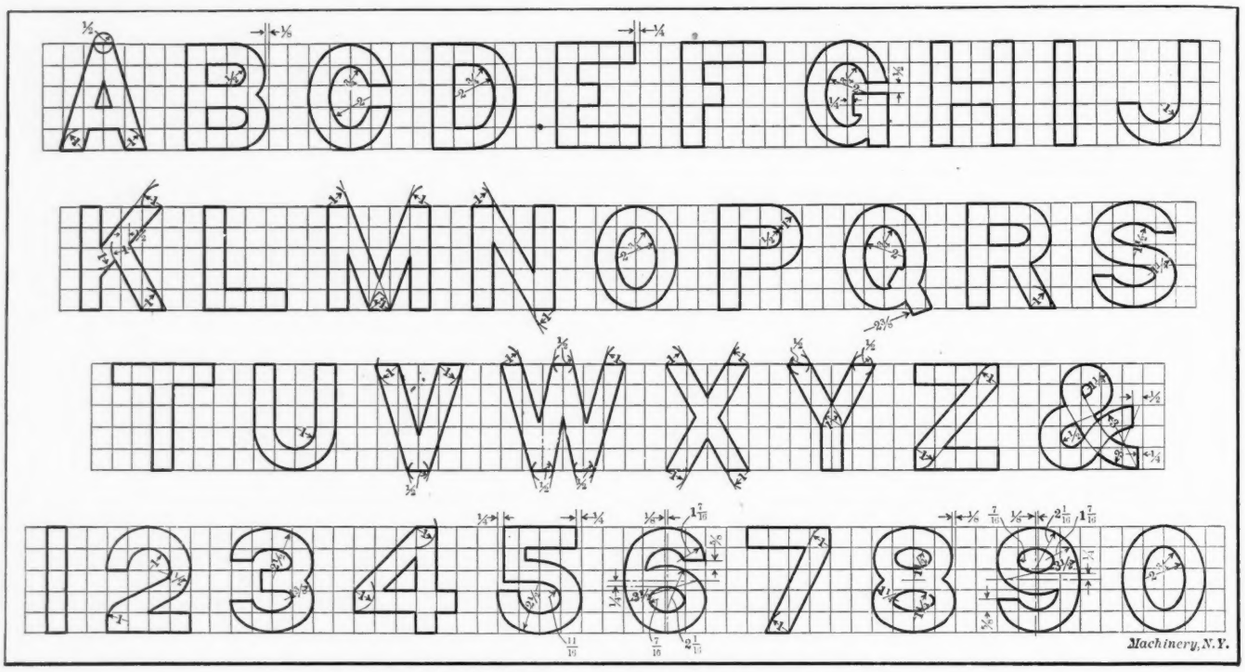


Diagram giving Proportions for Gothic Letters or Figures of Any Size

CLAMPING LONG AND SLENDER WORK

Good examples of both correct and incorrect methods of clamping a long, slender and rough casting are illustrated in the two fixture designs shown in the accompanying illustration. The piece to be milled, which is made of cast iron, is shown at *A* in the drawing. It requires a flat surface on top and two slots that must be milled straight, with only 0.0015 inch limit sideways. This is done in one cut with a gang cutter *C*. Four of the pieces are milled at the same time, but there is no reason why more than four could not be done at once, providing the milling machine table is wide enough.

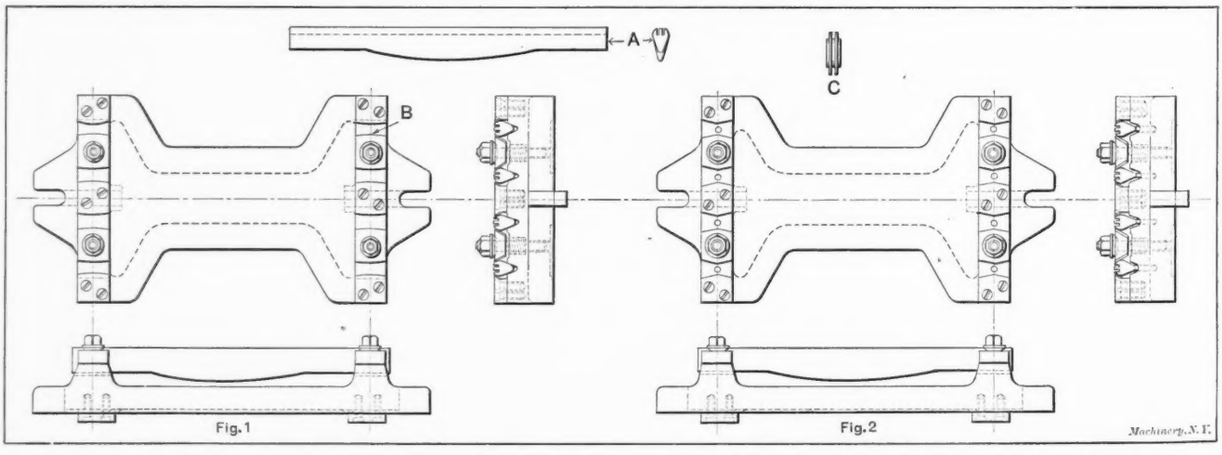
In Fig. 1 is illustrated a design of fixture for holding the work that is faulty. It will be seen that the clamps are rounded at *B* and that the work rests in V's, but although the clamps are rounded, the bearing that the work has in the V's will result in bending it. In Fig. 2 an improved design is shown. The clamps are pointed instead of rounded, and the work rests on points instead of V's, and for this reason it is not distorted by clamping.

It is obvious (but often ignored), that if a rough casting is clamped onto a flat surface it will be bent.

The vital difference, therefore, in the two designs, is that one clamps on surfaces and the other on points. When the job is clamped as shown in Fig. 1, it is held at each end by four points, that is, between two clamps and the two sides of the V, while in Fig. 2 it is in contact with only three points. One other important feature is that the points are all in line with each other, making it impossible to bend the work.

O. R. BARRETT

Luton, Bedfordshire, England.



Figs. 1 and 2. Two Fixture Designs Illustrating Incorrect and Correct Methods of Clamping Slender Work

DESIGN OF TOOL CHESTS AND CASES

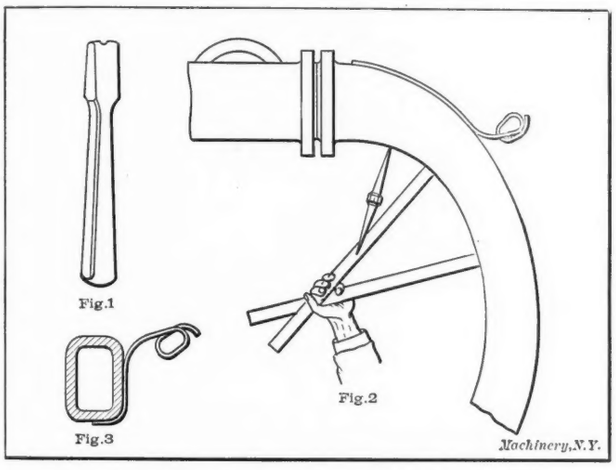
In the December number of MACHINERY there appears a suggestion by Mr. J. F. Winchester on the design of cases for small tools. As I am constantly on the road erecting textile machinery for a large English concern, I have had an excellent opportunity of finding out what is most needed in this direction. I obtained from one of your advertisers (Lyon Metallic Mfg. Co.) a steel machinist's tool-box, the weight of which is much less than that of a wooden one of the same size. When all the cases for micrometers, etc., were replaced by thin leather ones, which in my opinion answer the purpose much

better than the morocco cases that usually come with such tools, there was lots of room in the steel box and a great reduction in weight, which was important as I had continually to pay for the weight. I have been trying for some time to get a steel box for the heavier erecting tools, as wooden boxes, even when heavily banded, are constantly being split, to say nothing of the extra charges for weight. J. A. CALESS

Providence, R. I.

FINDING THE RADIUS OR SHAPE OF IRREGULAR PARTS

Mechanics in the various trades often find it necessary to obtain the radius or shape of irregular parts of machinery or patterns, thus making the use of templets necessary. Making templets, even when they are made from wood or cardboard, takes a great deal of time, and in many instances it is inconvenient to get at the work. For tool, punch or die work, metal templets are, of course, necessary. When great accuracy is not required, I have a method of obtaining irregular shapes which has proved satisfactory, and which will, doubtless, be of interest to many readers of MACHINERY. The shape of irregular parts may be easily obtained by the use of a piece of ⅛ inch soft solder wire. This wire is bent to conform to the shape of the work, but before this is done, it should be straightened and all small kinks that may be in it from previous use, removed. The wire is then formed to the



Illustrations showing the use of Soft Solder Wire for obtaining Radii on Locomotive Steam Pipe

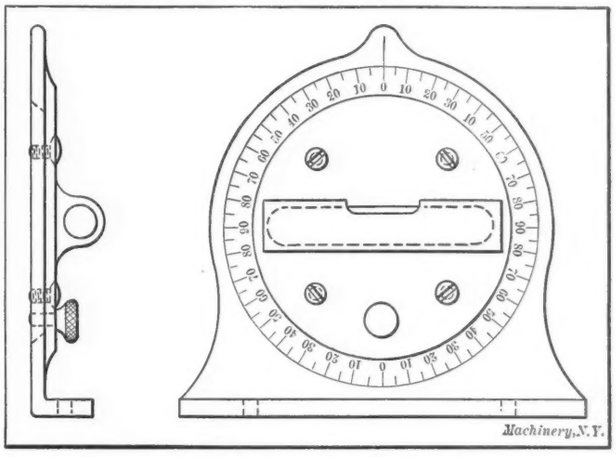
shape of the work with the end of a stick, such as shown in Fig. 1. When it is well formed and lies evenly it should be removed and laid on a flat board; then, by adjusting a pair of dividers until one point follows that part of the wire which was in contact with the work, the radius may be ascertained. Fig. 2 illustrates the application of the wire to a locomotive steam pipe which has many different radii, and irregular shapes that would be difficult to measure, especially with the pipe in place. This illustration also shows a very convenient way to get the inner radii. Two pieces of wood are held with one hand, as shown, and the dividers are held with the other, one point resting on the wooden support, while the other is adjusted to the correct radius. Fig. 3 shows the method of using the wire to get the radius on the cross-section of the steam pipe, which usually varies from end to end.

Chicago, Ill. C. V. FRISK

NEED OF A LEVEL ON THE MOTOR DRILL

It is time that a level was applied to the motor drill; at least, one similar to the kind used on a combination square which would not cost the maker much and would be appreciated when drilling horizontal or angular holes. The level shown in the illustration would be a convenient form, and it would enable the drilling of holes to any angle by setting the protractor to the angle required and then holding the level horizontal while drilling. The hole would then be at a corresponding angle and it would not be necessary to have someone to help keep the drill straight. I have used a loose level for this work, but such a level can only be applied when drilling a horizontal hole, without special arrangements, and even when the drill is in a horizontal position, the use of such a level is often impossible as some motors do not have a surface that is parallel to the drill, for leveling. In addition, when the motor is in action, both hands are required for holding the motor and feeding the drill. Therefore the level must be dispensed with and the position of the drill guessed at.

The level should be furnished by the maker of the motor, and the latter should have a face on the body parallel to the



Level and Protractor for the Motor Drill

drill center line, and two thumbscrews for holding the level so that it may be easily put on or removed.

I hope that this article will be read by both the makers and users of motor drills. It is, of course, very important to hold the motor as straight as possible when drilling, as side movements cause friction which not only requires more energy, but endangers the motor and temper of the drill, besides making the hole large or elliptical. Many broken drills are the result of this lateral movement when drilling, which could be avoided by the level attachment. A. NIELSEN

Cleveland, Ohio.

REPAIR JOB ON AN ALTERNATOR

The burning of a collector ring on three-phase rotary field alternator supplying current to individual motors, forced a tie-up in a factory putting out a food product which was highly perishable. Owing to the nature of the output and the in-

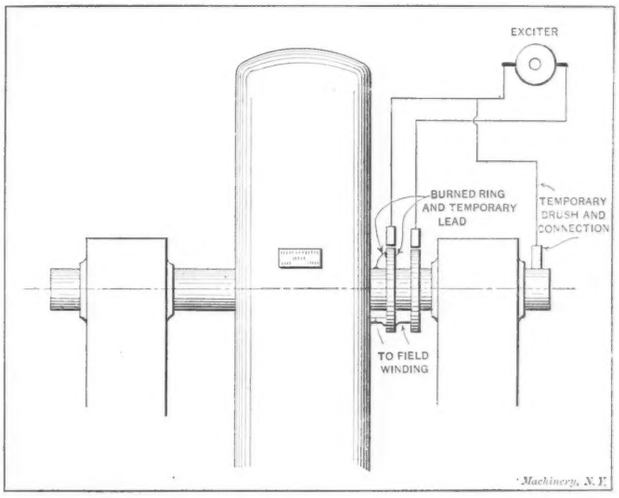


Diagram showing Temporary Repair of an Alternator with a Burned Ring

ability of the engineer to temporarily repair the alternator until a new ring could be cast, or one secured from the makers, a highly developed case of uneasiness attacked the management that was not relieved until a smart machinist made a suggestion, which he was allowed to carry out. His scheme, as simple as it was successful, is shown by the accompanying engraving.

The brush was first removed from contact with the burned ring. Then by setting the brush in a temporary holder, so that it was in contact with the shaft to which a lead from the burned ring had been soldered, the exciter circuit was closed. This completed the job, and in less than two hours the machine was again running, which it continued to do until the arrival of a new ring from the factory. So, what at first seemed to be a serious breakdown and loss, resulted simply in a slight delay.

DONALD A. HAMPSON

Middletown, N. Y.

ADDING, SUBTRACTING AND DIVIDING FRACTIONS

In making half-size drawings, it is often necessary to divide odd fractions by 2. I make use of the following method: Divide the whole number by 2; discard the ½; add the numerator and denominator together and double the denominator.

Example: Divide 15⅞ by 2. The half of the whole number is 7½, and discarding the ½ we have 7; the numerator added to the denominator = 15; and the denominator doubled equals 16, giving a total of 7 15/16. By this method it is very easy to do this mentally.

Here is another method for adding and subtracting fractions:

Example: Add 9 13/16 and 6 7/16. Subtract the difference between 13/16 and 1 = 3/16; subtract the 3/16 from 7/16 which is ¼. 13/16 and 7/16 added together gives more than 1 so carry the 1 and add the units which makes 16¼. This can also he changed by subtracting 7/16 from 1 = 9/16 and then subtracting that from 13/16 = ¼.

For subtraction, this method is reversed.

Example: Subtract 6 13/16 from 9 7/16. Add the difference between 13/16 and 1 to 7/16 = 5/8; carry the 1, and add 6 = 7; 7 from 9 = 2, and 2 plus ⅝ = the difference between the two numbers.

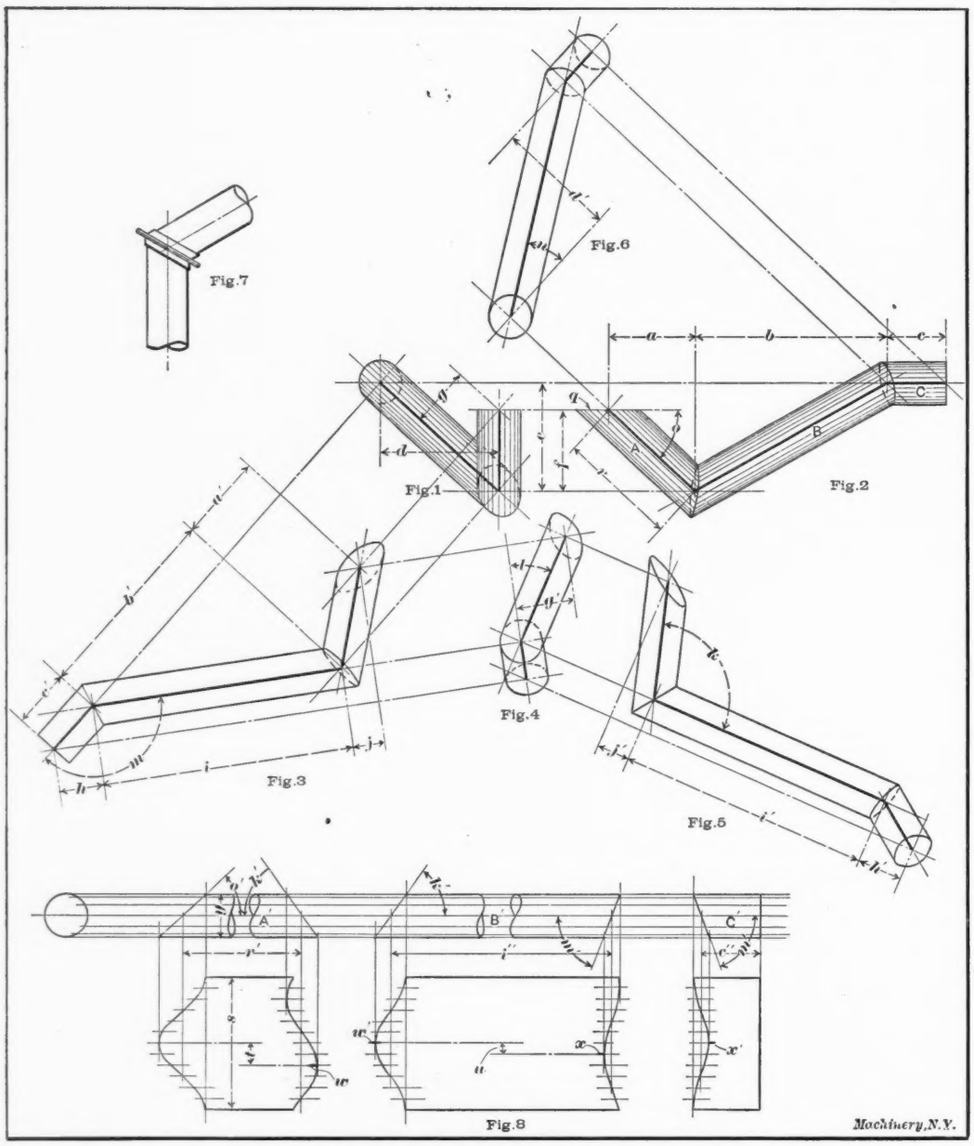
I have never seen the foregoing methods published; nor have I come across anyone who has used them, but I find them to be a great help to me.

FRANK W. HOLCOMB

Cincinnati, Ohio.

LAYING-OUT AND DEVELOPING THE SHEETS FOR STEEL SPOUTS

It might perplex one, who had not done similar work, to lay out and develop the sheets for a steel spout such as is shown in Figs. 1 and 2 of the accompanying engraving (in which *a*, *b*, *c*, *d*, *e*, and *f* are the given dimensions)) on account of the fact that the true lengths of and the true angles between the various parts have to be obtained before the sheets can be developed. However, the task is not as complicated as it might at first appear, as it is only necessary to work with the center lines. In the illustrations, the center lines are shown heavy and the spout parts are drawn in around them merely to better illustrate the principles involved.



Method of Laying-out and Developing the Sheets of an Angular Spout

Having drawn the views shown in Figs. 1 and 2, draw Fig. 3 making $c' = c$, $b' = b$, and $a' = a$; then m will be the true angle between the pieces B and C, and i will be the true length of piece B. Next draw the view, Fig. 4, making $g' = g$; then l will be the angle made by the center lines of pieces A and C when looking directly along the center line of piece B. Draw the view Fig. 5, making $j' = j$, $i' = i$, and $h' = h$; then k will be the true angle between the pieces A and B. Draw the view Fig. 6, making $d' = d$, and n will be the angle made by the major axis of face q and the center line of piece B when looking directly along the center line of piece A.

To determine the shapes of the flat sheets at the different joints, draw A', B' and C', making $r' = r$, $i'' = i$ and $c'' = c$. Make angle $o' = o$, $k' = \frac{k}{2}$ and $m' = \frac{m}{2}$. Develop the sheets in the ordinary way, as shown, making $s = y\pi$, $t = s\frac{n}{360}$ and $u = s\frac{l}{360}$.

If a lap joint is to be used, allowance must, of course, be

made for it. The sheets as shown should have their edges rolled up from the plane of the paper. When assembling the spouts, points w, and w', and x and x', should be brought together. The connections may be made with flanges as shown in Fig. 7.

CHAS. E. EVANS

Aurora, Ill.

TEST INDICATOR

The test indicator shown in the line engravings, Figs. 1 and 2, was originally designed for very accurate bench-lathe work, but it has since proved to be a handy tool for all

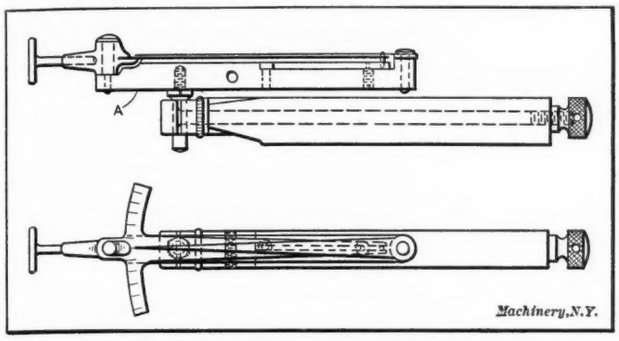


Fig. 1. Test Indicator for Accurate Work

kinds of work requiring accuracy. It is made so that it multiplies the errors in the work 120 times, or in other words, an error of 0.001 inch will show about ⅛ inch on the graduated scale. It will be noticed that the graduations extend from the zero at the center towards each side, so that both positive and negative errors are thus indicated. The design of the indicator can be easily seen by a study of Figs. 1 and 2. It consists principally of a body A made of tool steel and two levers and studs. The former is provided with two tapped holes, one on the under side and one on the front side. These holes are intended for studs by means of which the test indicator proper may be held to holders of different types. Examples of two kinds of holders are shown in the illustrations. The indicating device itself consists practically of only two thin levers, one of which is provided with a pointer indicating on a graduated scale as shown. The scale, of course, is graduated after the device is made, so that the graduations are exactly true. The points are made in disk form as shown in Figs. 1 and 2, but points of other shapes can, of course, be used

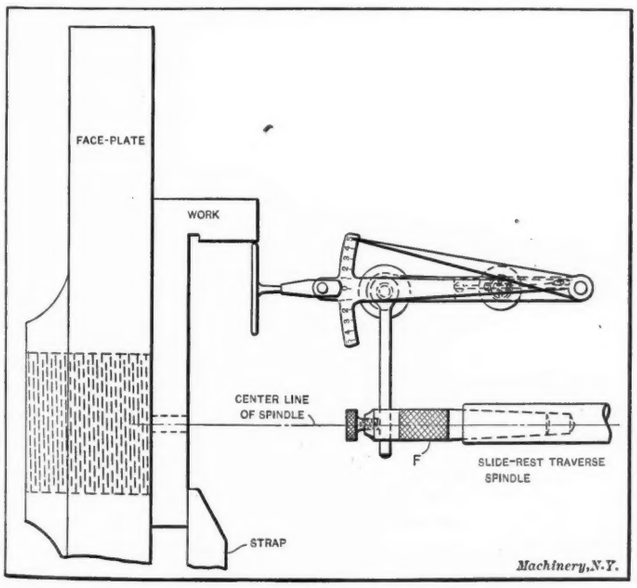


Fig. 2. Test Indicator in use for Setting up Work on the Faceplate

if preferred. Fig. 2 illustrates the use of the indicator in lining up work on the faceplate of a lathe. A number of different attachments may be made and used for special purposes, and holders of different kinds can be adopted. By means of these accessories the indicator may be used on nearly all classes of work requiring a high degree of accuracy.

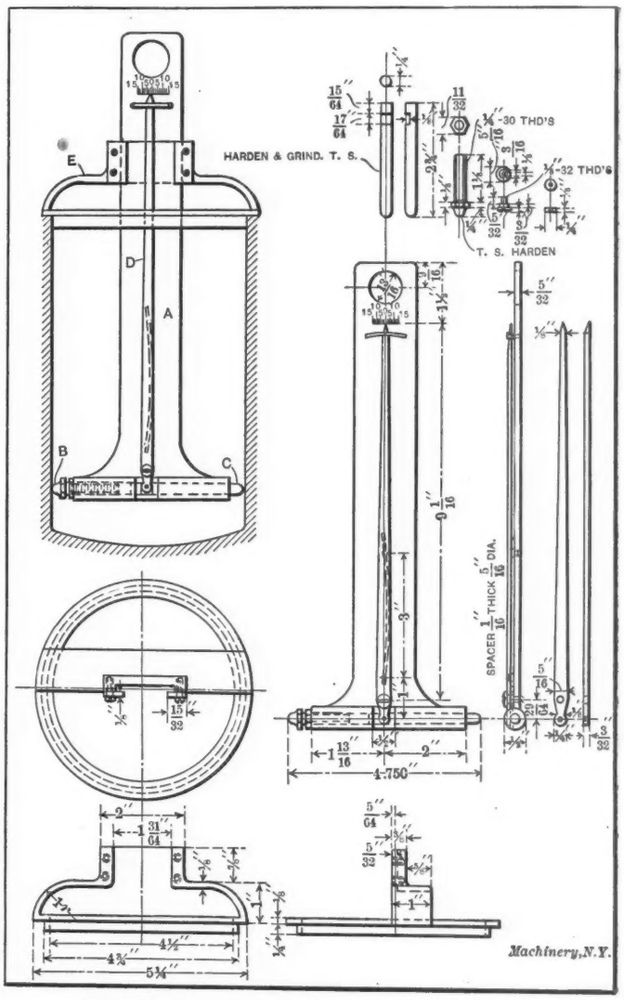
The uses of the tool will easily suggest themselves. A few jobs on which the writer has used it are for testing the lead of an engine lathe lead-screw, comparing it with a master thread plug; locating buttons in making drill jigs on the milling machine; truing up work held on the faceplate of the lathe, indicating either by a hole already bored, a center, or the outside of the work.

A. L. MONRAD

East Hartford, Conn.

DEEP HOLE CALIPERS

There has been considerable written of late on the subject of deep-hole calipers, and after studying the ones described in these columns, I have concluded that the type used at the Olds Motor Works is far more sensitive and accurate. These calipers indicate measurements within 0.001 of an inch, and



Assembled and Detailed Views of a Deep Hole Caliper for Testing Gas Engine Cylinders

they are used in our factory to test the size and alignment of the bore of gas-engine cylinders. As the variation allowed is but 0.001 it is essential that the calipers be well made to insure a long life and unimpaired accuracy. This, of course, makes the first cost considerable, but when the calipers are once finished they will last a lifetime.

These calipers consist principally of a body A, a fixed anvil B, and a movable anvil C which is connected with pointer D. The movement of this pointer along the graduated scale shown, indicates the variations in the cylinder diameters. To insure accuracy when the calipers are used by inexperienced hands, a guide E is used which fits the bore of the cylinder, as shown, and through which the outer end of the caliper passes. This guide so locates the calipers that the axes of the anvils intersect the axis of the cylinder and are at

right angles to it. Care is taken to have that part of the guide which enters the cylinder a very accurate fit. The ways into which the caliper body slide are carefully scraped to a perfect bearing.

The body of this caliper is a steel forging that is proportioned, of course, according to the size of the caliper. The anvil *C* is a sliding fit in a reamed hole in the cylindrical boss shown. The oposite anvil *B* is provided with a fine thread so that it may be adjusted when the calipers are being set to the size for which they were designed. A hexagon lock-nut holds this anvil securely in place after it is set in the desired position. Of course the caliper and guide are made for a specified size of hole.

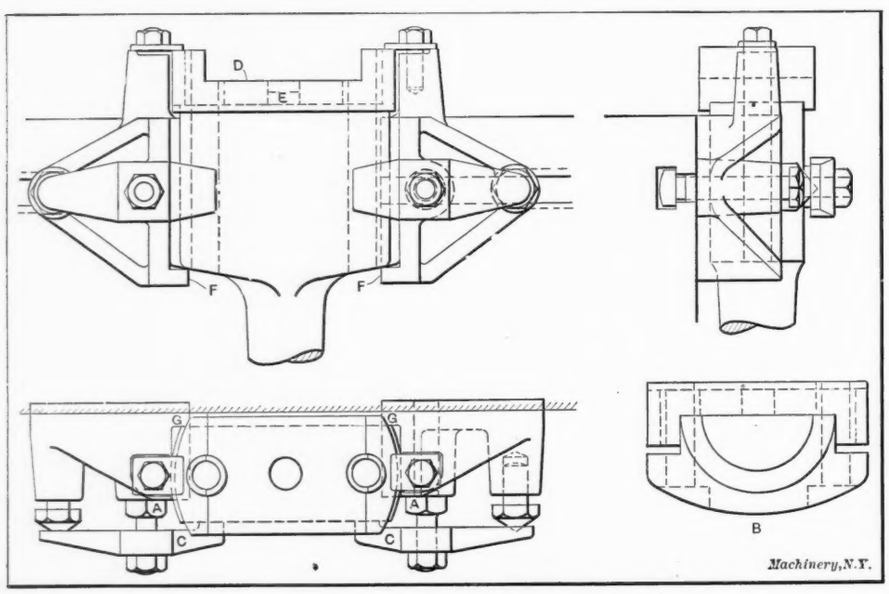
To determine the spacing of the graduation lines, an outside micrometer was set to the required dimension, and was made to bear heavily enough upon the movable anvil to bring the indicator hand to the center line. The threaded anvil was then screwed in or out until it came into proper contact with the anvil of the outside micrometer. It was then found that the point of the indicator hand had a movement of 1/50 inch, for a movement of 0.001 inch of the anvil. The caliper body was then securely fastened to an angle-plate and the graduation lines were put on with a height gage. The large hole at the upper end of the caliper body affords a hand hole that makes it more convenient to use the calipers.

This makes a very substantial tool, and it is giving perfect satisfaction in our inspection department. E. H. PRATT

Lansing, Mich.

DRILLING BOLT HOLES IN CONNECTING-ROD ENDS

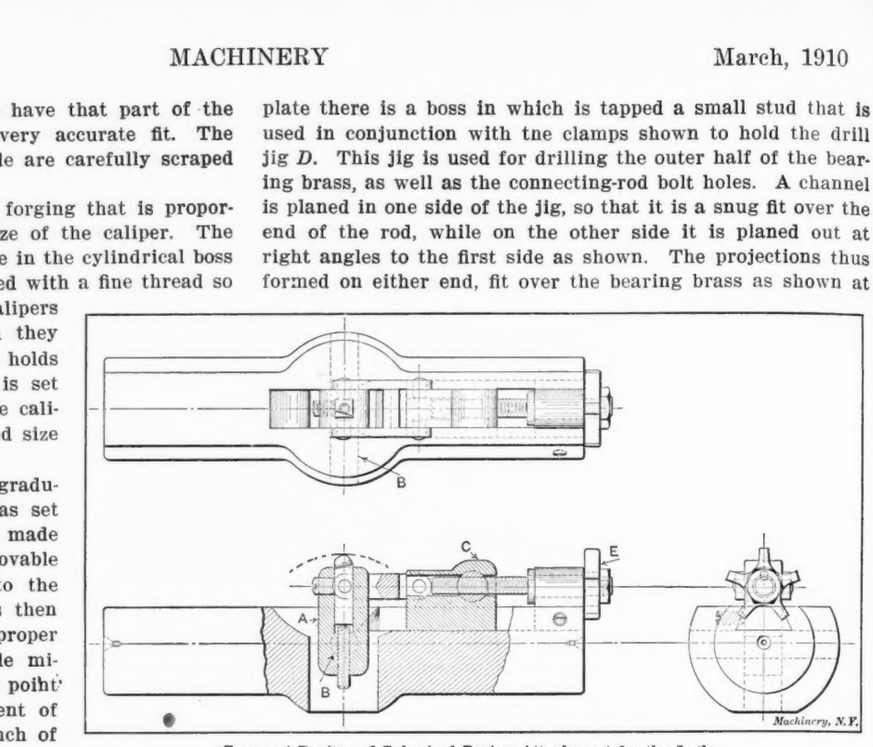
A pair of special clamps for holding and aligning gas engine connecting-rods while the bolt holes are being drilled, and also the jig used for locating the drill are shown in the accompanying illustration. The end of the finished rod is held between the two clamps or special angle-plates. These clamps each have a rib or tongue on the back that fits a T-slot of the machine table. In this way they are set parallel to each other and in line with the drill spindle. By tightening the nuts *A*, these plates are fastened to the machine. The same bolts that hold the plates to the table are also used for tightening the clamps *C*. One end of these clamps rests on adjustable screws with conical casehardened heads, which may be set to different heights to correspond with work of different thicknesses. On the top of each angle-plate there is a boss in which is tapped a small stud that is used in conjunction with the clamps shown to hold the drill jig *D*. This jig is used for drilling the outer half of the bearing brass, as well as the connecting-rod bolt holes. A channel is planed in one side of the jig, so that it is a snug fit over the end of the rod, while on the other side it is planed out at right angles to the first side as shown. The projections thus formed on either end, fit over the bearing brass as shown at *B*. The jig is further located for drilling the bolt holes in the rod end, by a central hole which fits the projection *E* on the rod.



Special Clamps and Jig for Drilling Connecting-rod Ends

After the connecting-rod is turned and planed, and is ready to be drilled, it is placed between the two plates which are movable sideways. The work rests on the lugs *F* and the plates are fastened, as before stated, by tightening nuts *A*. The rod is then clamped against the faces *G*. The drill jig is then placed on the end of the rod and lightly clamped against it. The drilling is then done by the usual method. When drilling the holes in the outer half of the crankpin brass, with the jig in the position shown at *B*, the tool steel bushings not only locate the drill properly, but take the side thrust while the drill is cutting on one side only, through part of the hole.

P. A.



Compact Design of Spherical Boring Attachment for the Lathe

SPHERICAL BORING ATTACHMENT

The design of spherical boring attachment illustrated herewith, is in use in one of the largest automobile concerns in the country. This attachment is used on the lathe in connection with a fixture that is fastened to the carriage for holding the work. It is held between the lathe centers and is driven by a dog. The boring tool is clamped in a tool-holder *A* that is attached to a pin *B*, which is free to turn in the bar. The upper end of the tool-holder is connected with a slide *C* by two links. Through this slide the feed-screw of the tool passes. As the bar revolves, the star-wheel *E* is actuated by a dog which is clamped to the tailstock spindle, thus giving the tool a circular movement about the axis of the pin *B*, as indicated by the dotted line. This movement combined with the regular rotary movement of the tool produces the spherical surface. G. R. RICHARDS

Brooklyn, N. Y.

* * *

TO GET THE FOURTH DIMENSION OF SPACE

Take a hecatonicocehedridgon and multiply by four,
A sexicocehedrigon plus half as many more;
Put in some polyhedrigons where gaps suggest a minus
And you will have a polyhedral-perpendodicahedrinus.

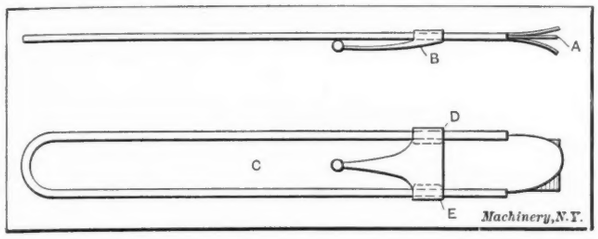
SHOP KINKS

PRACTICAL IDEAS FOR THE SHOP AND DRAFTING-ROOM

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary

TO PREVENT LOSS OF POCKET SCALE AND CASE

Nearly every man in the machine shop carries a six-inch steel scale, and often loses it because it so easily slips from his pocket. The device shown in the accompanying sketch has overcome this difficulty for the writer, and it is so simple and easily made that others may provide themselves with it

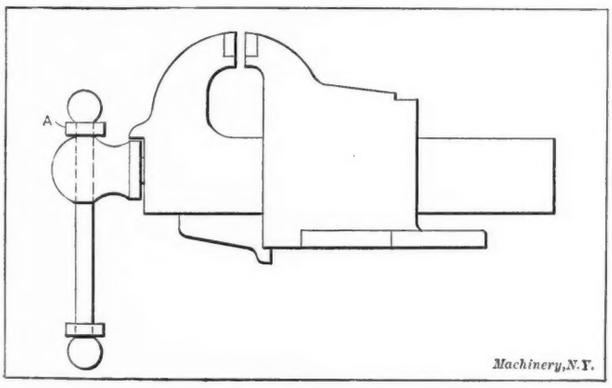


with very little trouble or expense. *A* is a 6-inch steel scale; *C* is a leather case which was purchased with the scale; *B* is a fountain pen "clip" which has been bent to fit the case and fastened in place with a little solder at *D* and *E*.

The clip should be so placed that it may grip the upper edge of the vest pocket, before the lower end of the case reaches the bottom of the pocket. W. H. K.

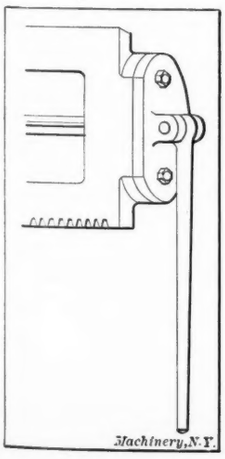
HAND PROTECTOR FOR VISE HANDLE

An excellent device for protecting the hand from a falling vise handle consists of a rubber ring *A* with a section about



⅜ inch thick by ½ inch wide, and having a hole a little larger than the handle. This ring can be stretched into place and when the handle drops it will not catch the skin and pinch it black and blue. A. G. JOHNSON

Two Harbors, Minn.



HANDLE FOR RADIAL DRILL ARM

Any one working on a large radial drill knows how difficult it is to move radially the arm when the head is raised. We have overcome this difficulty to a large extent by bolting a cast bracket to the end of the arm, to which is attached a handle as shown in the accompanying illustration. This handle, which is 24 inches long, is closely fitted to the bracket so that there is sufficient friction between it and the lugs to hold it in any position.

W. F. OLIVER

Plainfield, N. J.

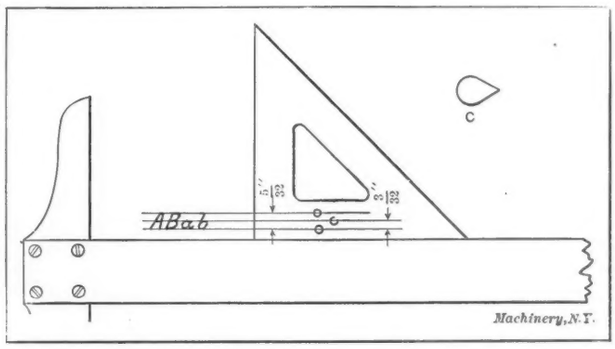
METHOD OF TESTING CANS FOR LEAKS

When searching for a leak in an automobile or bicycle tire, it is wet or placed in water so that the bubbles caused by the air will indicate the leaks. This same method is used by manufacturers of tin cans to find out if they leak before filling; but instead of putting an air pressure in the cans they are placed in a sort of conveyor, which after automatically putting a rubber cover on them, immerses them in hot water. The heated air in the cans expands, which causes bubbles to follow those which have leaks as they are carried along under the water; the defective cans are then picked out by an operator. HERMAN JONSON

New York City.

DRAWING GUIDE LINES FOR LETTERS

As many firms require a uniform height for the letters on drawings, the following scheme may be appreciated by those who draw guide lines for lettering in the usual way: Drill two or more 1/16-inch holes in a triangle, one above the other a distance equal to the height of the letters desired, as shown in the illustration. In this case the small letters are 3/32-inch high, and the capitals 5/32 inch. These holes are used

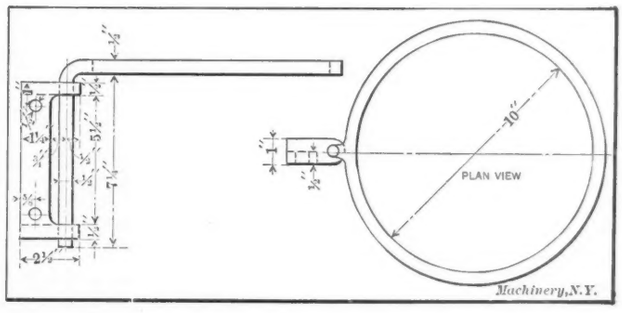


as a guide for the pencil, while sliding the triangle along the edge of the T-square. C. R.

[With round holes there will doubtless be some difficulty in drawing all lines to the same height, as the pencil point will not always be located in the same place. By making one side of the hole V-shaped, as shown enlarged at *C*, the pencil will be centered in the bottom of the V as the triangle is moved along.—EDITOR.]

BRACKET FOR WASH BUCKET

Many factories are without a wash room, the washing being done in buckets which are filled by a boy and set around the room in the most convenient place. By this method much water is spilled on the floor and spattered on the work. A good bracket for wash buckets is made as follows: Take a flat piece of machine steel of the dimensions shown in the accompanying sketch, and bend it at right angles at each end;



then drill one-half inch holes through the lugs thus formed. With a piece of one-half inch round iron, form a hoop to fit around the bucket, and also make a right-angle bend to fit the holes previously drilled through the lugs in the bracket. The holder is then ready to fasten to the bench, under which the bucket is swung out of the way when not in use.

E. H. PRATT

HOW AND WHY

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST

Give details and name and address. The latter are for our own convenience and will not be published

FORMULA FOR AREA OF LOCOMOTIVE EXHAUST NOZZLES

J. W. H.—Will you give me the formula for finding the size of the exhaust nozzles for coal-burning and wood-burning locomotives?

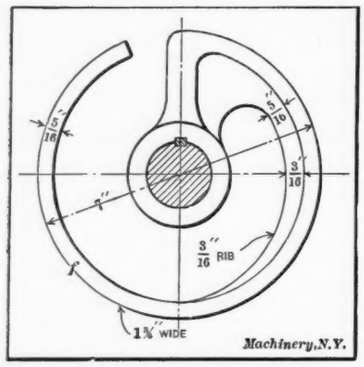
A.—The formula used by Mr. C. J. Mellin, consulting engineer of the American Locomotive Co., Schenectady, N. Y., for coal-burning locomotives is:

$$d = 0.156 \sqrt{\frac{S \times R}{S + 0.3\,R}}$$

in which d = diameter of the exhaust nozzle, R = area through tubes, S = grate area. All dimensions are in inches. For wood-burning locomotives, the coefficient 0.156 is changed to 0.140. The practice varies with different railway companies, however.

DESIGN OF EXPANSION BRAKE RING

J. D. R.—The expansion brake ring shown in the sketch is closed in ⅜ inch measured on the periphery, and turned to 7 inches diameter and placed in a case bored to fit. What is the radial pressure against the case when the ring is made of Parsons cast manganese bronze? The situation is similar to that of a piston ring in a cylinder except that one end of the ring is fixed on a central shaft instead of its having both ends floating as in the case of the piston ring.



A.—The question is submitted to our readers. It may be assumed that cast manganese bronze has a modulus of elasticity of 14,000,000. A treatment of concentric and eccentric piston rings can be found in Unwin's "Machine Design," Part II.

INVENTOR OF THE SENSITIVE DRILL

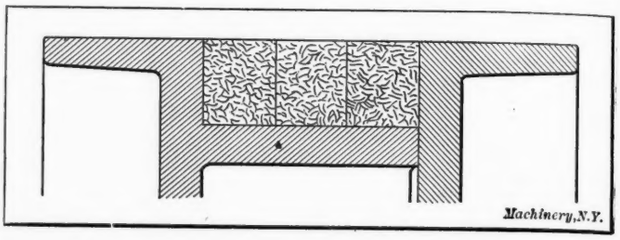
A. L. D.—Who invented the so-called "sensitive" drill, that is, the type in which the drill spindle is driven directly by a thin, narrow belt, and fed to the work by a directly connected hand lever?

A.—The invention of the sensitive drill, which was primarily made to prevent heavy breakage of small drills, is commonly credited to Dwight Slate, one time head of the well-known Dwight Slate Machine Tool Co., Hartford, Conn., who died in 1906. See MACHINERY, July and September, 1906. Mr. Slate's claim to the invention was not supported by the facts, however, and he failed to obtain a patent. In a letter by Mr. Frank H. Pierce, published in the *Hartford Courant*, August 11, 1906, shortly after Mr. Slate's death the following statement was made: "During the term of the late Hon. Ezra Clark as president of the National Screw Co., Mr. Slate was engaged as draftsman and he found there the sensitive drill set up and running as it had been for a long time before he went to work for the screw company. This drill was invented by Elijah S. Pierce, general superintendent of the National Screw Company, who also made the drawings for it and had it built and run under his personal supervision. Mr. Slate was quick to see the excellent mechanical points of the drill, and when he started a shop of his own the commercial value of it appealed to him. He began manufacturing the drill and sold a great many. He tried to get it patented but was unsuccessful."

PACKING FOR VACUUM PISTONS

E. A.—We have a vacuum pump of the vertical type that is equipped with water-packed pistons, and we have had considerable trouble keeping the vacuum pistons in good working condition. Will bronze rings work all right on a brass liner, and be an improvement on a solid piston?

A.—We would advise you to discard the water-packed pistons and replace them with ones having square fibrous packing. A packing of this kind which has been used for many years by a firm which manufactures a high grade of vacuum pumps, may be obtained from the Revere Rubber Co., 59 Reade Street, New York. The pistons should have a single groove, as shown in the engraving, that is wide enough for three of the fibrous rings. For pistons larger than eight or ten inches in diameter, a cast iron eccentric spring-ring should be inserted beneath the fibrous rings, to set them out against the cylinder wall. This spring-ring, while not absolutely necessary, should, preferably, be employed in connection with comparatively large pistons when a high vacuum has to be maintained. The groove in which the fibrous rings are placed should be somewhat wider than three times the width of the packing, as the latter is expanded considerably by the moisture which it absorbs. For the same reason the depth of the groove, when the spring-ring is not used, should be slightly in excess of the thickness of the packing. These fibrous rings should also be cut a little less in length than the piston circumference to allow for elongation. When the rings are finally inserted, the joints should, of course, be separated to prevent leakage. The amount of expansion may be determined by soaking the rings in water until they are completely saturated. If the packing swells to such an extent as to cause the piston to stick, the trouble may be overcome by removing one or more of the thin strips or layers which form the packing, from the side of one of the rings. For pistons in the neighborhood of ten inches in diameter, the size of the packing should be about ½ inch square. For larger pistons up to 18 or 20 inches, the packing should be from ¾ to 1 inch square. This fibrous packing will be found more satisfactory for a vacuum pump than metallic rings, though babbitt rings, which are also set out by a cast-iron spring-ring, have been used with considerable success.



* * *

PROCESS FOR COATING STEEL WITH COPPER

Copper-coated steel has been on the market for several years and is much used where strength is required with ability to resist corrosion and erosion, as in the case of steam turbine blades. A process has recently been made public for coating steel with copper that is of interest. A steel billet that has been given a preliminary treatment is immersed in a bath of copper at a temperature so high that the surface of the billet is partially dissolved; the steel unites with the copper and forms a steel-copper alloy coating on the billet that firmly adheres when withdrawn from the bath. The billet is next placed in a mold, great care being exercised to prevent the destruction of the alloy film by oxidation, and a final coating of pure copper, which readily welds to the previously alloyed surface, is cast around it. In this way the two metals are so firmly united as to withstand sudden temperature changes, drawing, cutting and mechanical manipulation generally. When drawn through dies the reduction of cross-section areas of copper and steel is almost exactly proportional to their original areas in the billet.

* * *

A large German electrical concern uses its erecting shop for advertising purposes in a very effective way. On each large casting is painted in white letters the name of the customer of the machine for which the casting is intended, together with the size and capacity of the complete machine. Visitors and prospective customers are taken freely through the shops so as to be duly impressed in favor of the firm, as they find that their friends or competitors have already placed orders.

NEW MACHINERY AND TOOLS

A MONTHLY RECORD OF APPLIANCES FOR THE MACHINE SHOP

MILLED SCREW AND MACHINE CO.'S UNIVERSAL THREAD MILLING MACHINE

The machine illustrated in Figs. 1 to 4 inclusive, is a universal thread milling machine, made by the Milled Screw & Machine Co., of Sayre, Pa. The points of interest in the design relate particularly to the simplicity of the mechanism, the avoidance of delicate or rapidly revolving members, and the support and driving of the work in a way which insures freedom from all avoidable strains arising from cutting or driving.

The machine consists essentially, as will be seen in Figs. 1 and 2, of a bed of the lathe type, carrying at one end a headstock mechanism by which the lead-screw is fed forward and rotated; and at the other a spindle-driving mechanism by means of which the cutter is driven, while set in any angular position required by the thread being cut. It will be seen that the work and the lead-screw are mounted on the same axis, so that the strains are taken in a straight line, with no possibility of bending or overhang. The lead-screw is of unusually large diameter to resist torsional stresses, and is mounted over the center of the bed. The blank to be threaded is gripped in a chuck connected directly with the end of the lead-screw. The screw at this end is carried by a sliding carriage, which gives it the necessary support. The blank is gripped from the outside and no centers are used or required.

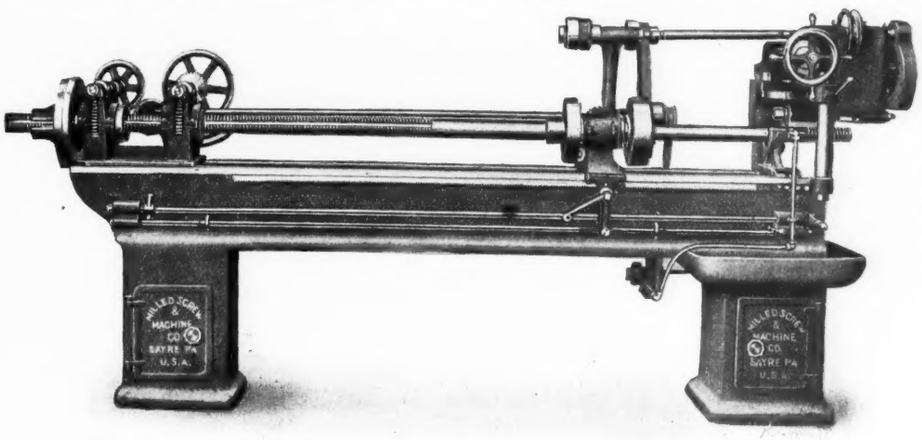


Fig. 1. Universal Thread Milling Machine, of Direct and Simple Design

The Cutter Head

Details of the cutter end of the machine are shown in Fig. 3. Power is received from the countershaft on the grooved pulley *A* at the top of the head. This is connected by suitable gearing with the cutter spindle, the whole being mounted on a swiveling bracket provided with graduations as shown at *B*, which permit it to be set to the calculated helix angle. The cutter head is supported at both the front and the back of the bed. The work is held directly beneath the cutter by a bushing in rest *C*, which is cut away at the top to allow access to the work. The adjustment for depth of cut is made by handwheel *D*, which is provided with a large diameter dial reading to thousandths of an inch.

The feed and revolving motion for the screw to be cut is obtained from driving pulley *A* through shaft *E*, with which it is connected by universal joints. The joint at the right is placed directly over the axis of angular adjustment of the cutter head, so as to make a minimum of change in the end position of the shafts. The bracket *F* supports a countershaft arrangement which, by means of the two sets of cone pulleys shown, gives nine rates of feed to the work for each cutter speed. From here the motion is conducted through shaft *G* to the feeding head at the rear of the machine, which is more clearly shown at Fig. 4.

The Lead-screw Controlling Mechanism

The lead-screw *H* of the machine is solid, of large diameter and carefully made. It passes through the hub of worm-wheel *J*, to which it is keyed and from which it receives its rotary motion. It is free, however, to slide through it axially. Worm-wheel *K* has mounted on its outer hub a disk *L*, which carries jaws *M*, bored to form a nut for engaging the thread of lead-screw *H*. By a construction very similar to that of the ordinary two-jawed chuck, these half nuts *M* may be closed down on the lead-screw or withdrawn from it, permitting the screw and the work connected with it to be freely moved in an axial direction. Worm-wheels *K* and *J* are driven from shaft *G* through worm-gearing at *N*. The worms driving *J* and *K* are connected by change gears *O* and *P* and idler *Q* as shown.

Setting the Change Gears for Various Pitches

The relation between the rotating and threading movements in the head shown in Fig. 4 will best be understood by first considering the simplest case—that of cutting a screw of the same pitch and hand as the lead-screw. For this case idler *Q* will be thrown out of engagement, so that worm-wheel *K* and half nuts *M* remain stationary. Under these conditions, as lead-screw *H* and the worm connected with it is rotated by worm-wheel *J*, it will advance through the stationary nuts *M* in the exact proportion to its lead, giving the same pitch to the work. To cut a finer pitch of the same hand as the lead-screw (which is left-hand as shown in the engraving), the disk *L* with the half nuts would be so connected with *J* through change gears *P* and *O* that it would revolve in the same direction as the lead-screw but at a somewhat slower feed. For left-hand pitches coarser than the lead-screw, the nut *M* is evidently revolved in the opposite

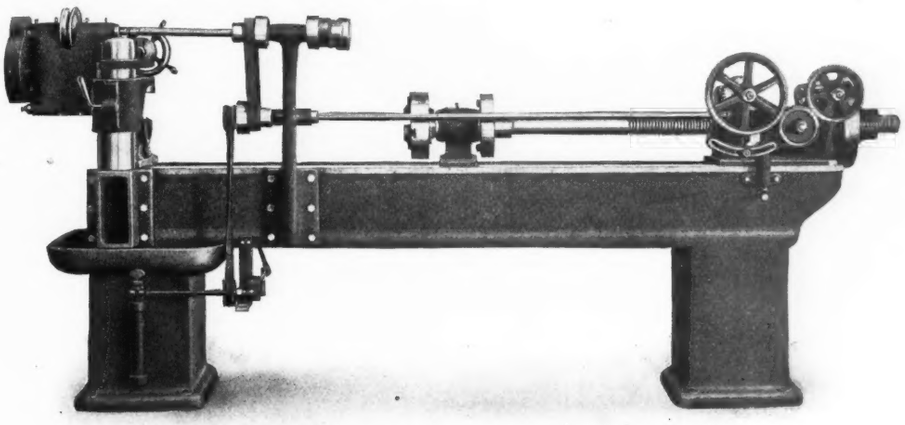


Fig. 2. Rear View of Thread Milling Machine, showing Feed Connections

direction to the lead-screw so as to give it a more rapid travel, and consequently produce a coarser pitch.

For cutting right-hand threads the work and lead-screw will evidently revolve in the opposite direction from that required for left-hand threads, if it is to feed in the regular way from left to right in Figs. 1, 3 and 4. If nuts *M* were stationary and the lead-screw were revolving in this direction, it would evidently feed to the left. In order to make it feed to the right, we must revolve nuts *M* in the same direction as the lead-screw, but at a faster rate. The faster the nut is revolved, the coarser will be the pitch.

The requirements may thus be summarized as follows: For right-hand pitches, gear *O* revolves faster than gear *P* and in the same direction. For left-hand pitches finer than that of the lead-screw, *O* revolves in the same direction as gear *P*, but at a slower rate. For left-hand threads of the same pitch as the lead-screw, gear *P* is stopped altogether. For left-hand threads of a coarser pitch than the lead-screw, gears *O* and *P* are connected so as to revolve in opposite directions. This would evidently require the introduction of another idler in addition to *Q*.

The Sliding Head and Provision for Multiple Threads

The forward end of the lead-screw is supported in sliding head *S*, where connection is made with the short spindle carrying the chuck *T*, through the medium of the flanged coupling *R*. The work is grasped by chuck *T* and supported in bushing *C* as has been previously mentioned. When nuts *M M* are released from the screw, head *S* may be rapidly adjusted to any point on the bed by means of the crank and rack and pinion movement shown. An automatic feed stop is also provided for limiting the length of thread cut. This operates a clutch which forms the connection between shaft *G* and the feed driving worm-wheel *N*, and is manually controlled by lever *U*.

The purpose of the coupling *R* is to permit the cutting of multiple threads. When the bolts in this coupling are loosened, the work may be revolved with respect to the lead-screw, making provision for double, triple, quadruple threads or worms, etc., as may be desired. The index is accurately

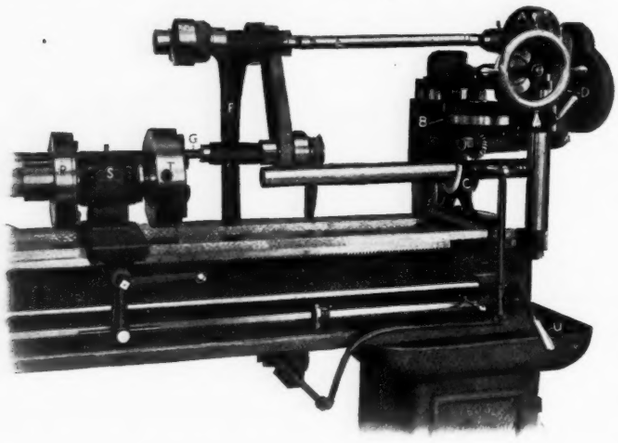


Fig. 3. The Cutter Drive and Work Support

made, and permits great accuracy in the division of the threads.

For any except complicated decimal pitches, the nuts *M* may be released and the head run back by the rack and pinion movement after the cutting of each thread of a multiple screw. In order to engage properly again, the same precautions would have to be taken as when running the carriage back by hand for threading in the lathe—namely, for odd pitches the lead-screw should be stopped and the carriage run back an exact number of inches; for even pitches, an exact number of inches or half inches, etc.

General Features of the Design

The simplicity and directness of action of this machine is one of its chief characteristics. Its simplicity enables it to be sold at a moderate price, makes it easy of operation, and reduces expense for maintenance and repair. In the matter of directness the salient point is the provision of a lead-screw of large and stiff proportions, directly over the center of the bed, with the blank to be threaded gripped in a chuck directly at the end of the lead-screw. The work is supported of the bed, with the blank to be threaded gripped in a chuck lar bushing of the exact size of the blank. All the threaded portion is therefore free from strain after passing the cutter. This arrangement avoids any bending of the blank due to the side pressure of the tool or cutter, and obviates the buckling due to the heating of the blank that would be met if it were held between rigid centers.

The simplicity of the mechanism for revolving and feeding the screw should also be noted. The double worm drive gives a smooth, direct and powerful motion to the screw, and to the work which is directly connected with it. This permits a full depth of thread to be machined at each operation with a

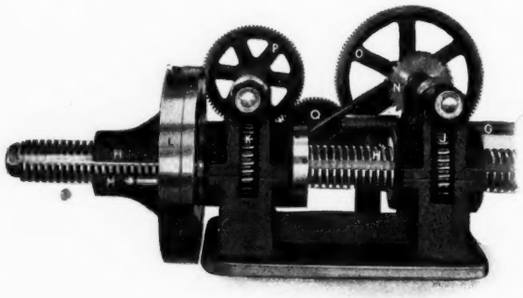


Fig. 4. The Lead-screw Revolving and Feed Mechanism

minimum of chatter. The reducing ratio of the worm drive varies from 60 to 1 on the large machine, up to 100 to 1 on the lightest size. This avoids the use of large and complicated gear trains, auxiliary shafts, movable carriage and bearings, and numerous small details, all subject to wear and strain.

This machine is built in three sizes, each having a capacity for work of maximum diameter of 6 inches, and ranging from 2 to 21 feet in length. The machine will be furnished with motor drive if required. The safety of the belt drive should be noted, however, as the failure of any or all the belts will not damage either the machine or the work under any condition.

An extra attachment will be provided if required for cutting keyways. A variation of the style of machine here illustrated provides for a vertical spindle, using a formed end mill in accordance with the method pursued in cutting the worms for some makes of Sellers drive planers.

AVERBECK 17-INCH SHAPER

In the November, 1906, number of MACHINERY, in the department of New Machinery and Tools, we illustrated a 21-inch shaper made by the H. J. Averbeck Shaper Co., of Covington, Ky. The novel features which were incorporated in the design of this shaper have recently been applied to a smaller machine of the 17-inch size, which we herewith illustrate and describe.

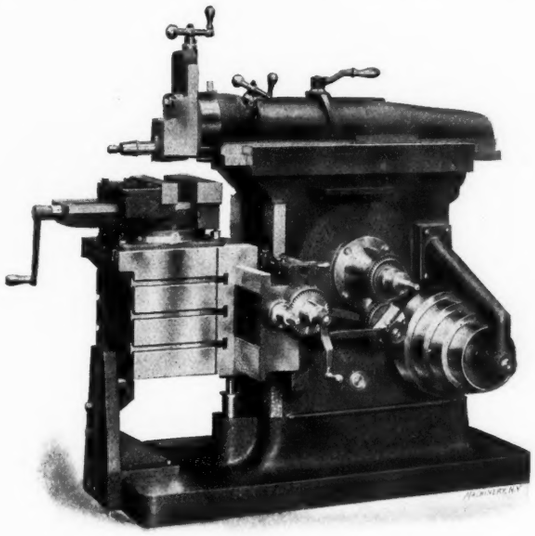
The design, of course, includes the features which have been found necessary for machine tools in the past few years in the matters of providing increased rigidity of the structural members (the column, ram, table, etc.) together with ample driving power for using high-speed steels to the limit of their capacity. The machine is back-geared. For direct connection the ratio between the gear and the ram is 5 to 1, and with the back-gears 18 to 1.

The cross-rail is of unusual construction. It is deeply ribbed and very heavy. The power cross-feed has the advantage of being provided with an automatic stop, controlled by two dogs, which may be set for use when cutting in either direction. Two stationary dogs are also provided which cut out the feed at the extreme travel of the table, avoiding any possibility of breakage at these points. The lever shown just above the gearing at the end of the rail, engages, disconnects or reverses the feed. The operation of the cross-feed screw by 2 to 1 gears provides for a slow or quick hand movement as

may be desired, as both shafts are squared for the wrench. The cross-feed screw has a graduated collar reading to 0.001 inch, and has 16 feed changes ranging from 0.008 to 0.125 inch per stroke.

The table is slotted on both top and sides. It is of such construction that, in combination with the form of rail used, bolts may be entered from the back as well as from the front. It has four T-slots on the top. These provisions facilitate the clamping of work. The vise has a graduated swivel base, and can be clamped on either side or the top of the table. When the table is removed, either the vise or the work itself can be clamped directly to the front of the apron, T-slots being provided at this point as well.

Attention should be called to the table support, which is bolted to the front of the base. The roller slide can be conveniently set to the vertical travel of the table in any position. It is evidently dirt proof, as contact with the roller is made on an inverted horizontal surface. This table support is always



Averbeck 17-inch Back-geared Shaper, with Automatic Cross Feed Stop

directly beneath the cutting tool, and so is adapted to take up the strains in the most effective way.

The down-feed screw of the tool block is provided with a double collar, one keyed to the screw and the other provided with a friction slip, and graduated to 0.001 inch. The provision of the keyed collar prevents any possible accidental change of the graduated collar from the position for which it is set. The head swivels to any angle and is graduated.

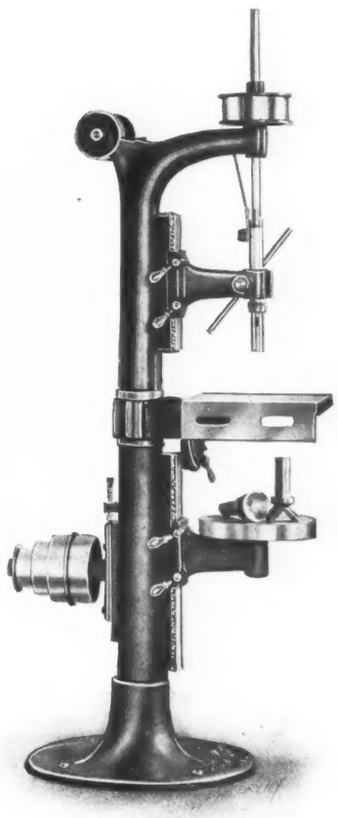
Great care has been taken in the general design and workmanship of this machine. All the shaft bearings in the column are well braced and of ample length, and are provided with suitable oil channels, fitted with dustproof plugs. All the T-slots are cut from the solid and (as may be seen from those shown on the apron in the engraving) are cut deeper than usual to prevent breaking out. All the bearings, such as those of the ram, rail, tool-block, crank-wheel slides, etc., are provided with taper gibs, so as to permit the maintenance of the accurate fit originally given these parts.

BARR NO. 7 TOOLMAKER'S DRILLING MACHINE

The No. 4 drilling machine made by H. G. Barr, 21 Hermon St., Worcester, Mass., was found so convenient for toolmakers that a heavier machine was demanded for this use. The resulting design is shown in the accompanying engraving, where it will be seen that a very stiff frame and drive has been provided, together with all the various attachments and adjustments needed in a machine which is to meet the varied requirements of the toolmaker's work.

This drill is provided with a sliding spindle head, a vertically adjustable round table, and a square table mounted on a swinging bracket. The square table can be tilted about a horizontal axis as well as swung about a vertical axis, so that it may be used for drilling holes at any angle. It is located in the horizontal position by a tapered dowel pin. One side of the table is provided with an extended bearing surface, with T-slot holes for clamping, adding greatly to its convenience in the holding of certain classes of work. It has a working surface of 13 by 14 inches. The round table is 12 inches in diameter, and can be removed from its supporting bracket to permit the use of the cup and V-centers provided. Binding handles are provided for locking the vertical adjustment, as well as for the various adjustments of the square table, and of the sliding spindle head.

The spindle is turned from a steel forging and is carefully ground to size and hand draw-polished. It is 1 inch in diameter, 35 inches long, and provided with a No. 2 Morse taper hole. The feed movement is 5½ inches, through a steel rack and pinion and a self-fastening feed lever, which does away with set- and thumbscrews. Ball bearing thrust collars are provided at the lower end of the quill and a fiber washer with a splined collar and spanner nut at the top. The cone and driving pulley on the rear of the machine is provided with a screw belt tightening adjustment as shown. All the pulleys are turned inside to give correct balance. All sliding surfaces are carefully scraped to their bearings and given a frosted finish. All the machines in this builder's line are tested to 0.00075 inch in 10 inches as the maximum allowable amount of error in lining up the spindle with the surface of the work-table.



Universal Sensitive Drill for Toolmaker's Use

The No. 7 size here shown weighs 515 pounds with the countershaft. It will handle any drill up to ¾ inch in diameter.

DUDGEON "UNIVERSAL" HYDRAULIC JACK

The hydraulic jack is so old and so simple a piece of mechanism that there would seem at first thought to be little chance for the display of ingenuity in improving its construction. The original inventor, however, Richard Dudgeon, Broome and Columbia Sts., New York City, has succeeded in developing a new construction which is of enough interest to warrant the description and illustration here given.

An example of one of the various styles of this new "universal" jack, as the maker calls it, is shown in Fig. 1. It is similar to older designs in its external appearance with the exception of the small valve handle in the head of the ram. This handle operates the lowering mechanism, and also controls a system of valves which, through the action of a double piston, gives two rates of pumping for the jack, permitting it to be used for the maximum load at regular speed, or for one-half the load at twice the speed. This double-pump arrangement is also useful, of course, in rapidly bringing the ram to any desired height before the load is applied. The functions controlled by this handle operate through an extremely simple construction, and this simplicity and directness of construction, in combination with the double pump

and the improved lowering connections, constitute the main points of interest in the new design.

The Universal System of Pistons and Valves

In describing the action, attention is first called to the diagram shown in Fig. 2, where is shown the pump as set for the rapid movement under one-half the normal load. The cistern or water supply is located at *A*, while the ram *B* is lifted by the water in cylinder *C*. The pump plunger is shown at *D*. This has two diameters, as shown, the full diameter working in chamber *E*, and the reduced diameter in the lower chamber *F*. The larger diameter is so proportioned to the smaller that it gives twice the area. The effective area of the pump plunger in chamber *E*, however, is the same as in chamber *F*, the area of the smaller diameter being subtracted from it.

Fig. 1. Dudgeon Double-pump Plain Hydraulic Jack

A continuous passage extends from cistern *A* to cylinder *C*. In this passage three valve seats are provided as shown, closed by valves *G*, *H* and *J*, which may be simply held upward in their seats by water pressure as shown, or by springs. With the usual construction, the lower valve *J* is the only one provided with a spring. By the operation of plunger *K*, as will be described later, one, two or three of these valves may be forced from their seats.

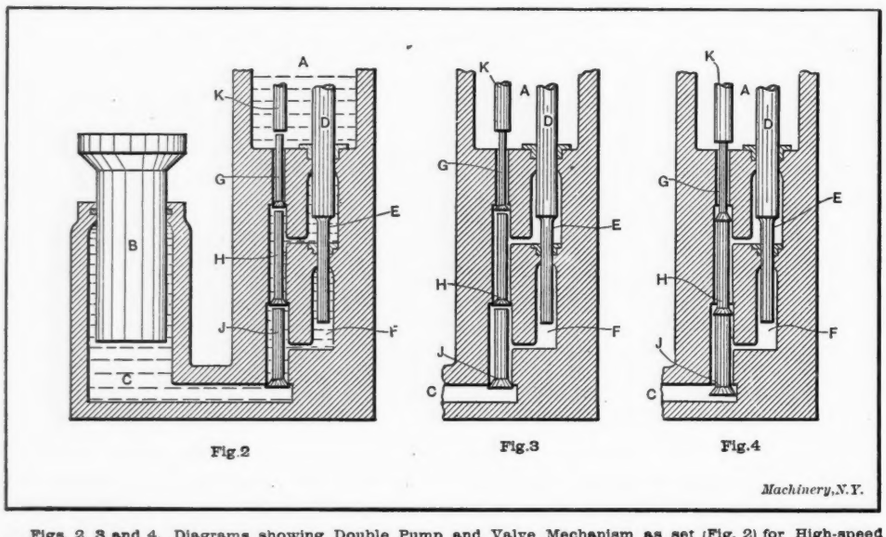
Fig. 2, as stated, shows the arrangement of the parts when the pump is working at its highest speed under one-half the normal load. As plunger *D* is pressed downward, the liquid is forced out of the chamber *E*, past the valves *H* and *J* into *C*; and out of chamber *F*, past valve *J* alone into *C*. When plunger *D* is raised, the pressure in *C* seats valve *J* firmly, while valves *G* and *H* drop from their seats, allowing a new supply from the cistern *A* to flow into chambers *E* and *F*. The repetition of the up and down strokes evidently forces the water from *A* into *C*, and raises the ram. It will be noted that under these conditions valve *H* is open on both up and down strokes, being thus inoperative when the jack is working as a double-plunger pump.

Fig. 3 shows the pin *K* pushed down far enough to hold valve *G* open permanently. Under these conditions it will be seen that when the ram is forced down, the water in chamber *E* is pushed back past valve *G* into the cistern again, instead of into the cylinder, while that in chamber *F* passes valve *J* into *C* as before. In this way, valve *H* is seated during the downward stroke and thus becomes operative. On the upward stroke, the pressure in *C* seats valve *J* as in the previous case, to close communication with the cylinder, while water is drawn into *E* and *F* through *G* and *H*, the latter of which drops from its seat to permit the flow. Under these conditions the continued up and down movement of the ram forces water from chamber *F* only into cylinder *C*, thus giving one-half the rate of movement of Fig. 2 and twice the available pressure. The higher pressure is due, of course, to the fact that the same pressure on the ram is applied to only the smaller area at the lower end in chamber *F*, instead of in both *E* and *F* as before. The water in chamber *E*, it will be seen, is merely churned in and out of cistern *A* without going to the cylinder.

For lowering the jack under the load, pin *K* is pressed still further downward as shown in Fig. 4 until it has unseated all three of valves *G*, *H* and *J*, permitting the liquid to flow directly back from *C* into *A*. The raising of *K* again far enough to permit the seating of valve *J* at once checks the lowering of the ram and holds the load at any desired position.

Application of the Principle to the Jack

The mechanism whose principles have thus been illustrated is practically applied to the jack in a way seen best in Fig. 5, where a vertical cross-section is shown. The cistern or reservoir is located in the head and barrel of the ram. The piston is operated as usual from a rockshaft and an outside lever, pivoted in the head. The chambers for the large and small diameters of the pistons are formed in a pump cylinder bored out in the lower end of the ram. In this ram is also formed the passage in which the three valves are mounted. The pressure valve, which is the last of these, is provided with a removable seat and a spring for holding it in the closed position.



Figs. 2, 3 and 4. Diagrams showing Double Pump and Valve Mechanism as set (Fig. 2) for High-speed Pumping using Both Pistons; (Fig. 3) for Slow Speed and Maximum Capacity, using Lower Piston only; (Fig. 4) with all Valves held open for Lowering the Load

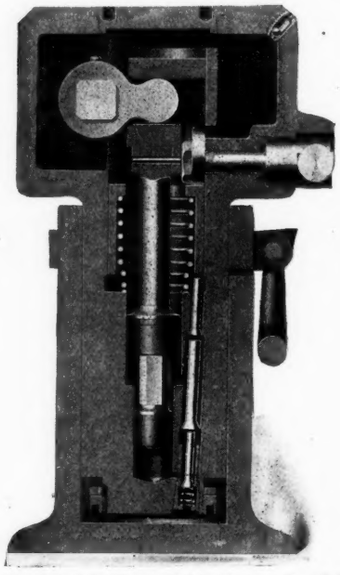


Fig. 5. Ram with Pump and Valve Mechanism operating on the Principle illustrated in Figs. 2, 3 and 4

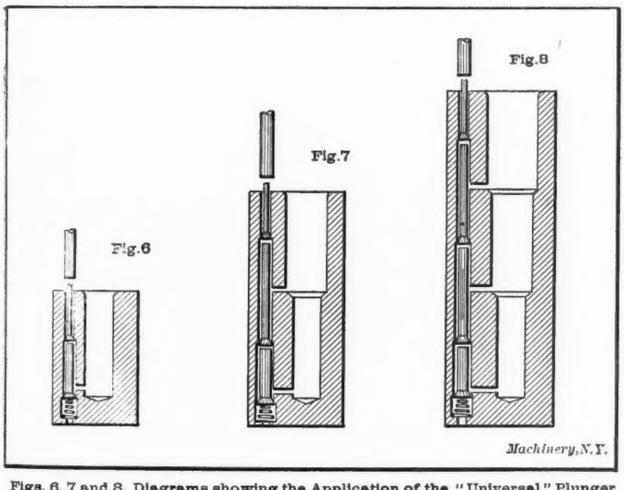
Instead of using a pin *K*, as in Figs. 2, 3 and 4, for forcing down the valves for the various conditions of operation, a sleeve is used. This is forced down to the double stroke, single stroke, or lowering positions by the operation of the valve handle, which carries a cam on its inner end, operating on the upper edge of the sleeve. The latter is held up against this

cam by a spring under its lower end, as shown. The lower edge of the sleeve bears on the top of the valve stem, which is thus operated in a manner identical with that shown in the diagrams. The sleeve may also be depressed for lowering by throwing the pump-lever to the extreme lower position. When this is done a pin on the crosshead strikes the top of the sleeve, opening all the valves and bringing about the conditions shown in Fig. 4. To permit the lever to take this extreme downward position, it is reversed in the socket as with the ordinary construction of jack, so that the lug is upward. This lug in the operating position stops the movement before the lowering position is reached. The exterior construction is plainly shown in Fig. 1.

The Adjustability of the Jack

The reason for having a sleeve instead of a rod, *K*, as shown in Fig. 2, for operating valves *G*, *H* and *J*, is to permit the head to be turned on the ram, or the cylinder to be turned in the same member, and still have the controlling mechanism for the valves operative. Whatever the positions of either, the cam on the valve handle and lowering pin *P* are always in line with the upper edge of the sleeve; and the stem of the valve is always in line with the lower edge. This is necessary, because the joint between the head and the ram is a threaded one, so that no assurance can be given that it will be re-assembled in exactly the position it had when originally put together.

The same thing applies, in other styles, to the cylinder ram. The ram in such cases is provided with a pin which may be entered in any one of four holes in the cylinder flange, which may thus be given four positions. This construction is of especial advantage when using the ram horizontally. As the tool is regularly assembled, the ram when used horizontally has the lever projecting straight up, while the three valves are on the lower side of the ram. This permits the use of sufficient water from the cistern to permit the use of the full stroke of the ram. In some places, however, it would be more convenient to have the pump lever project to one side or the other, or even (in special cases) vertically downward, in order to give room for easy manipulation. To meet



Figs. 6, 7 and 8. Diagrams showing the Application of the "Universal" Plunger and Valve Construction to Single-, Double- and Triple-action Pumps

these exigencies this provision of four positions has been made. To change the position it is only necessary to withdraw the ram from the pump, unscrew the pump retaining ring, and shift the position of the dowel pin in the flange of the cylinder. The ability to use the ram for the full stroke any side up in the horizontal position, is an important advantage of this new design.

It should be noted that the particular ram shown in Fig. 5 is designed for car inspectors' work and always used in a vertical position, so does not clearly show the nature of the adjustment when applied to jacks of other styles.

The Points of Improvement

The points of novelty in this universal jack may be summarized as follows: It provides a double-pumping mechanism giving two rates of lift, applicable to a general purpose hydraulic jack. When the load is light, the double pump will raise it with twice the rate of speed for a single pump. When the load is heavy, one-quarter turn of the handle will throw out the action of one pump, and will give the action of a single pump jack.

It provides for this double-pump action and the control of the lowering by the simplest valve construction imaginable. The valves are assembled in one chamber and only three are needed (two suction and one pressure valve) of which only two are ever in use at one time. Other double-pump jacks require at the least five valves, and three passages between the pressure chamber and the reservoir, and each closed by a separate valve, and the failure of any one of these valves or

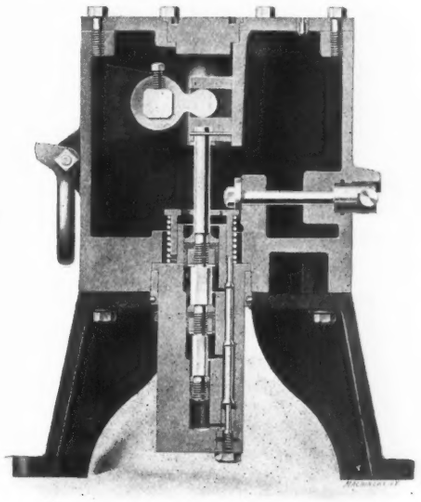


Fig. 9. Hand-operated Cistern Pressure Pump, embodying the Triple Plunger Principle shown in Fig. 8

of either cylinder packing renders the pump inoperative. It will be seen by referring to Figs. 2 to 5 inclusive, that two cylinder packings or three valves would have to be thrown out of commission before the load would be released with this type of jack. The advantage of the construction from the point of safety and the prevention of serious accidents is undeniable.

It can be lowered by either the lever or the valve handle. As the valves can be operated by the handle independently of the pumping mechanism, they may be opened and cleared of any obstruction which prevents their proper seating by the working of the pump. This often obviates the necessity for dismantling the mechanism.

Ease of dismantling the pumps, valves, etc., for this jack is another advantage of its construction. This will be best appreciated from Fig. 5. Access to all the valves is provided by the removal of but one bonnet. When the ram is removed from the cylinder, the unscrewing of this bonnet permits the three valves, and the removable seat, to drop from the passage in which they are confined. Furthermore, to remove the piston for the examination of the packings of the plungers, it is only necessary to unscrew the cap in the top of the ram, when it may be freely withdrawn.

The instant and absolute control of the lowering mechanism by the handle should also be included as one of the advantages of this jack. This control of the lowering is, in fact, one of the prime advantages that the hydraulic form possesses over the mechanical types of jacks. With the latter the lowering is hardly less laborious than the raising. No additional valves are required for this releasing movement. The position of the valve lever indicates at all times whether the lowering valve is open or closed.

The general design of this tool has been carefully looked out for, to preserve the qualities of lightness, portability, simplicity and reliability. It will stand rough usage, and not get out of order. It has the minimum number of parts. These are so assembled as to be easily replaceable when necessary. The whole device can be easily taken apart and put togther without special tools.

Triple-action Pumps built on the "Universal" Principle

That the new design of plunger and valve mechanism used in this jack is, as its name indicates, "universal" will be appreciated after a study of Figs. 6, 7 and 8. Fig. 6 shows the single plunger, single chamber and double valve arrangement. Here, evidently, the plunger is single-acting and the ram has but one rate of speed. The depression of the two valves under the action of the lowering pin would permit the release of the load. In Fig. 7 is shown diagrammatically the arrangement shown more elaborately in Figs. 3 and 4. Here we have two chambers, two rates of pumping speed, and provision for lowering.

In Fig. 8 the construction is carried still further, and provision is made, as shown, for three chambers and four valves arranged as before. With all the valves free to act, all three chambers would be forcing water into the cylinder. By depressing the uppermost valve, two chambers only would be in operation. By depressing still further the two upper valves, but one chamber would be in operation. And finally, by depressing all four valves, the load would be lowered. It would be possible, but perhaps not practicable, to carry this multiplicity of valves and pistons to any extent, giving three, four or any number of rates of pumping speed. Two, however, is sufficient for all the practical purposes for which a portable jack is used.

Fig. 9 illustrates a pressure pump for hydraulic work in which the triple piston arrangement shown diagrammatically in Fig. 8 has been used. There are thus, in this case, four working positions to the handle, giving three different rates of pumping, in addition to the lowering position. This cistern pump may be used for a great variety of purposes, such as for making tests, or on the operation of variable pressure hydraulic presses, etc. It may be connected to any piece of hydraulic apparatus by means of flexible copper tubing. It will be furnished to give any combination of pressure required—such as, for instance, 1,000 pounds to the square inch with three pumps in operation, 2,000 pounds with two pumps, and 6,000 pounds with one pump.

Other Hydraulic Machinery

A wide variety of other hydraulic apparatus has been designed by the makers of these jacks, incorporating the principles of the mechanism we have described. Horizontal jacks, jacks for bridge builders, car inspectors, etc., hand hydraulic pumps, power hydraulic pumps, jack cylinders for hydraulic presses, etc., are some of the various styles. In the last case, the ram is provided with a rack and pinion adjustment which permits the rapid bringing down of the platen against the material to be pressed, without requiring the tedious operation of the pump for this idle movement.

All these pieces of apparatus are composed of parts which are simple in themselves and which may be replaced when necessary at a low cost. The parts are interchangeable, being made by automatic machinery, and are easily dismembered without the use of special tools.

IMPROVED DESIGN OF BINSSE BORING MACHINE

The boring machine built by the Binsse Machine Co., Newark, N. J., is of the standard type in which the spindle is mounted in fixed bearings on a column or headstock, while the work is clamped to a table adjustable by both longitudinal and cross motions on a knee, which latter member is itself adjustable vertically by means of two connected elevating screws. The type will be readily recognized from Fig. 1. The makers of this machine have recently made important improvements in the design, which should add to its convenience and productiveness.

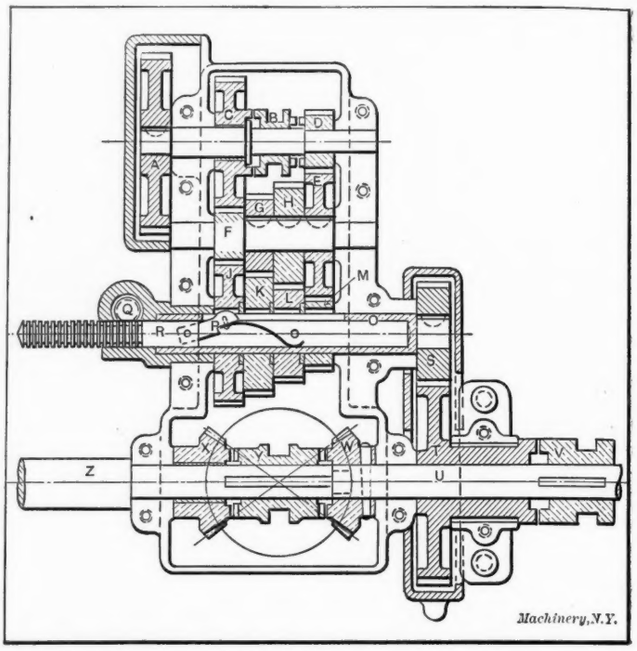


Fig. 2. Arrangement of Gears in Quick Feed Change Mechanism

One of these improvements consists simply in lengthening the arms of the pilot wheel at the extreme left of the machine, by which the boring-bar is advanced toward or withdrawn from the work. This improvement, simple as it would appear to be, is yet of great advantage, as it permits the workman to shift the bar without moving from his position of observation at the working end of the spindle. He is thus enabled to center the spindle to a punch mark, and do similar work accurately to dimensions, without the inconvenience of stepping back and forth between the pilot wheel and the working point.

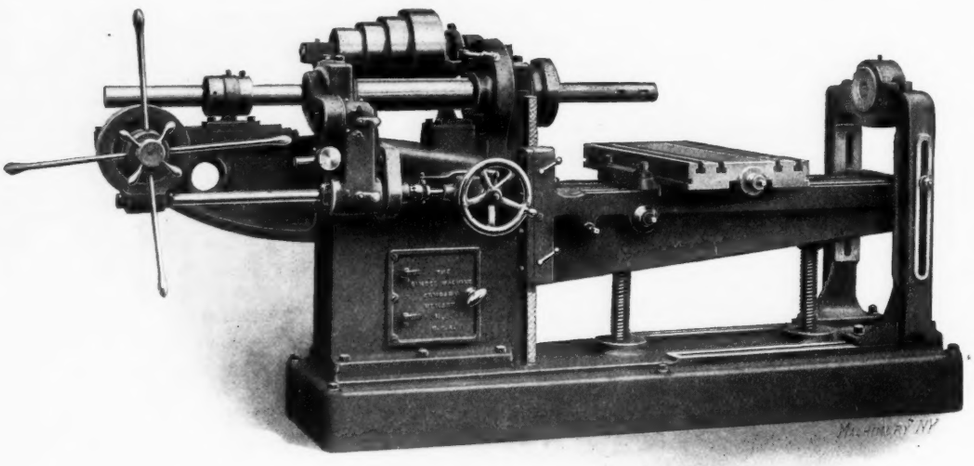


Fig. 1. Binsse Boring Machine with Improved Feed Gearing and Other Details

A second improvement relates to the means provided for clamping the work-table to the saddle and the saddle to the knee. This provision consists of four bolts, one passing through each corner of the saddle. The lower end of each is provided with heads fitting in T-slots on top of the knee, while the nut on the upper end tightens down on a clamp, which enters the gib slot in the edge of the work-table. When the nuts are screwed up, it will be seen that with this arrangement the table is clamped to the saddle and the saddle to the knee simultaneously, the strain being taken directly down from the table to the knee, giving the most rigid possible construction. This is similar in principle and effective-

ness to the method which has always been provided on this machine for clamping the outer end of the knee and outboard support together. This consists, as may be seen, simply of a through bolt laid on the top of the knee, and passing from side to side of the outboard support through slots formed to receive it. When the nut on the outer end of this bolt is tightened up, the sides of the support are drawn against the knee and the whole structure is clamped together. It will be noticed that square locked gibbed surfaces are used throughout the machine. This is the construction that gives the greatest rigidity and the best fitting sliding bearings.

A third and the most important improvement is the provision of a geared feed drive of the quick change variety. This change gear mechanism has been worked out in very attractive form. As may be seen in Fig. 1, it is compact and designed in harmony with the rest of the machine. It is also very easily manipulated. It provides for a reverse motion and for eight feeds, any one of which may be instantly obtained. These changes are effected by the operation of two levers and a knurled knob.

Fig. 2 shows details of the construction of this change gear device. Gear *A* is driven by intermediate gears from the spindle of the machine. On the shaft to which it is keyed is also keyed sliding clutch member *B*, which may be set to engage with clutch teeth in either of gears *C* and *D*. The clutch is operated by the upper of the two short levers shown on the feed box in Fig. 1. Gears *D* and *C* mesh respectively with gear *E*, and an integral pinion on the shaft *F* to which it is keyed. *F* may thus be given two speeds depending on whether *B* is engaged with *C* or *D*. *F* also carries two other gears *G* and *H*. *F*, *G*, *H* and *E* mesh respectively with gears *J*, *K*, *L* and *M*, which revolve loosely on the hollow shaft *O*. Either of these four gears may be connected with *O* by means of the diving key *P*, which may be moved from one to the other of its four positions by means of a pinion *Q*, meshing with circular rack teeth turned in the outer end of the plunger *R*, in which *P* is pivoted. *R* is operated by the knurled knob shown at the side of the feed box in Fig. 1, and thus controls four changes, which, in combination with the upper crank, give the eight for which the mechanism provides.

Gear *S*, keyed to shaft *O*, meshes with gear *T* running loosely on shaft *U*; the latter is connected by bevel gears with the handwheel at the right of the column. To connect or disconnect *T* with *U*, and thus start and stop the feed, clutch *V* is provided. Bevel gears *W* and *X* and clutch *Y* control the direction of the feed. Gear *W* is pinned, as shown, to shaft *U*, and *X* is connected with *W* by an idler bevel gear so that it revolves in the opposite direction. Clutch *Y* is keyed to shaft *Z*, which extends backward to drive the worm on the pilot wheel shaft. It will be noted that shafts *Z* and *U* are separate, the former having a pivot bearing in the latter at their junction.

It would be very difficult to effect the same number of changes, with a smaller number of gears than that used by the combination shown in Fig. 2. Ten gears only, as may be seen, are required for giving the eight changes of speed. All the mechanism is enclosed in a dust and grit proof casing, with ample provision for lubrication.

The means provided for clamping and centering the boring-bar in this machine is original and effective. A split and tapered bushing surrounds the bar in the nose of the spindle. A steel collar, threaded on the outside and tapered to fit on the inside, surrounds this bushing. When the collar is screwed into the spindle, its taper presses in on the bushing, forcing it together and tightly gripping and centering the bar.

This tool retains all the features which have become well known in the boring machine made by this firm. The base is of unusual depth and rigidity, as may be seen. This gives stiffness to the whole machine. The driving cone is mounted on a shaft, separate and to the rear of the spindle, and is provided with internal back-gears. The arrangement gives a drive particularly suited to heavy facing cuts and other hard service, and relieves the spindle of the belt pull.

The makers have found that it is possible with this type of boring machine to maintain a high degree of accuracy in the alignment of the spindle with the top of the table. The maximum error in parallelism between them allowed is 0.0005 inch per foot, and most of the machines turned out come considerably within this limit.

The machine illustrated in Fig. 1 is the No. 2B size. The boring-bar of this machine is 2¾ inches in diameter and is made of high carbon steel with a No. 5 Morse taper hole. The direct gearing ratio between the cone and the spindle is 1 to 4½; and through the triple gearing, 1 to 18. The eight feeds range from 0.004 to 0.100 inch per revolution. The bar is held by friction at any point and can always be given the full length of feed at one setting.

PAWLING & HARNISCHFEGER HORIZONTAL DRILLING AND MILLING MACHINES

The firm of Pawling & Harnischfeger, of Milwaukee, Wis., has developed a line of horizontal boring and drilling machines comprising three different sizes and two different designs. Examples of each of the designs are illustrated herewith: Fig. 1 shows the largest or No. 7 size with the solid box casting column, while Fig. 2 shows the No. 5 machine

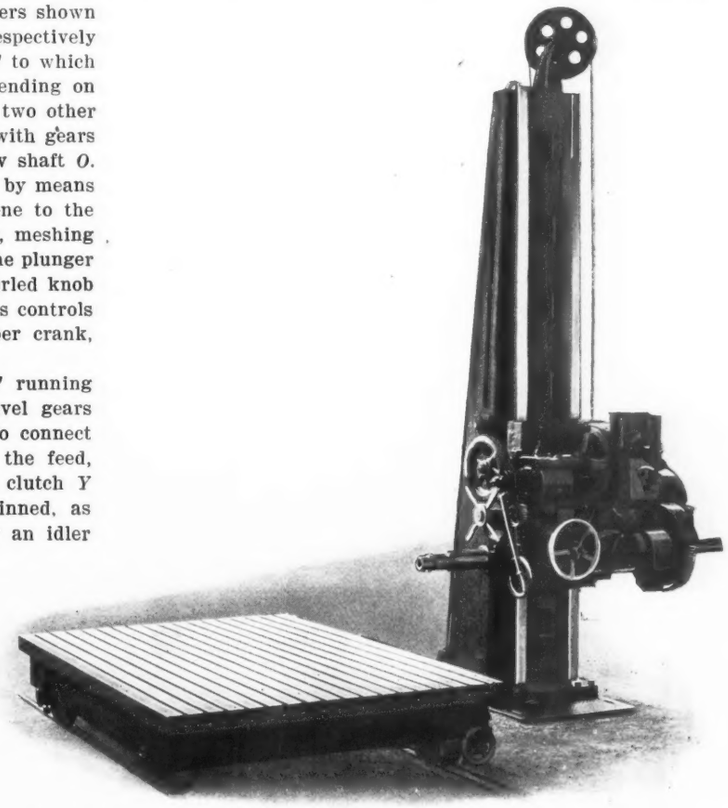


Fig. 1. No. 7 Horizontal Drilling and Milling Machine, with Box Type of Column

with a column built up of cylindrical members. The feed and driving mechanism on the spindle saddle is similar for the two machines, although in Fig. 1 the motor is mounted on the saddle while in Fig. 2, it is placed on the top of the column. The two designs are also similar in that the column is bolted in place on the floor, while the work is mounted on a table which rolls on a track, thus giving the required longitudinal adjustment.

The No. 7 machine, shown in Fig. 1, will cover a working surface area of 65 square feet, for drilling and tapping holes up to 3 inches in diameter. The saddle has a vertical movement of 7 feet 8 inches on the column. The speed and feed control is arranged conveniently with relation to the operator's position. A positive clutch engages the motor pinion and is operated by a lever at the front of the saddle. This also controls the reverse as well. The feed is locked or unlocked and the spindle advanced or withdrawn by one hand-

wheel. The spindle is of high carbon forged steel with extended bearings which assure alignment at the extremes of travel. The end thrust is taken up by dust-proof ball bearing. The saddle is balanced by a counterweight inside the column.

The table has a length of 8 feet, and a width of 6 feet. It is adjusted by barring the capstan heads provided for the purpose on the axles. The table is fitted with improved roller bearings, large diameter axles and chilled wheels. A clamping brake on one axle, operated by the handwheel shown, provides for locking in position when desired. For boring with long bars, an adjustable outboard bearing is used, clamped to the table and lined with the work and the spindle.

The machine is easily adapted to portable use, as it may be unbolted from its base and swung by the crane into any desired position for operating on large castings. A three-horse-power motor is required for the No. 7 machine. Eight changes of spindle speed are furnished, ranging from 7 to 200 revolutions per minute. The spindle is 2 7/16 inches in diameter, has a No. 5 Morse taper hole and a feed of either 24 or 30 inches as may be ordered. Four feed changes are provided for each spindle speed. The weight of the machine itself is 8,300 pounds; the weight of the table is 9,250 pounds.

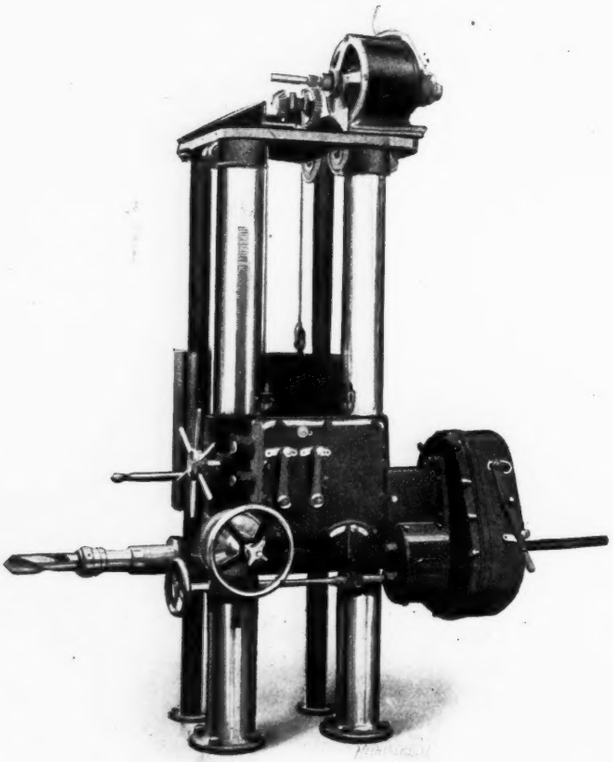


Fig. 2. No. 5 Machine, with Frame built up of Cylindrical Members

The No. 5 machine, shown in Fig. 2, has about the same capacity as the No. 7 machine so far as size of spindle and maximum diameter of drilling is concerned. The work-table, not shown in the engraving, is 8 feet long and the vertical adjustment of the spindle carriage is 5 feet, giving approximately 40 square feet of area available for a working surface. The columns of which the frame is formed are held in position by top and bottom plates, the latter of which is bolted to I-beams embedded in the floor. These are extended to support the two rails on which the work-table travels. The counterweight for the saddle is guided by two pipes that are also retained in the top and bottom plates, making the machine practically self-contained.

As in the previous case, the machine is driven by a three horse-power motor through mechanism which gives a similar range of speeds. The rotation is reversible for tapping and for back counterboring, by the operation of a lever within convenient reach of the operator.

The weight of machine, counterweight and table combined is 12,841 pounds. It will be noted that no overhead support or pit under the floor is required. The machine may be belt-driven, if desired, by the substitution of a driving pulley for the motor.

WESTMACOTT GAS FURNACES

The accompanying engravings show three new members of the line of furnaces made by the Westmacott Gas Furnace Co., of Providence, R. I. Fig. 1 shows an oven furnace which has been redesigned throughout. The burners have been improved in efficiency and the furnace has a new and more effective form of lining. The door is 12 inches wide and 6 high. The heating space is 18 inches long. It may be employed for hardening or case-hardening tools, die blocks or other pieces of carbon or machinery steel, and may be advantageously used as well for annealing metals of any kind.

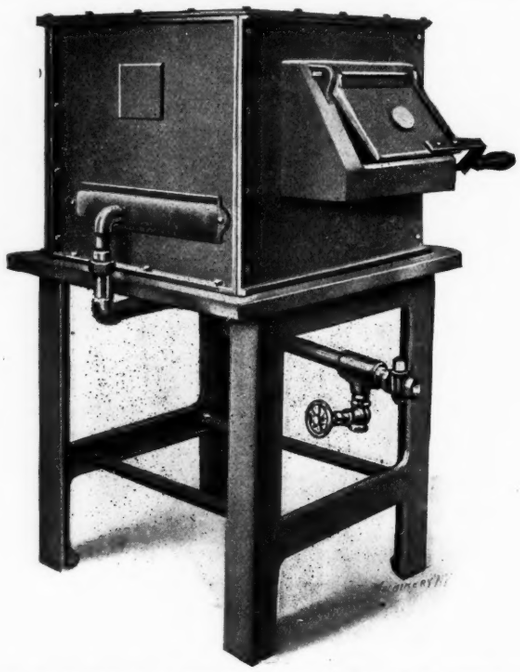


Fig. 1. Westmacott Oven Furnace for General Heating, Hardening, etc.

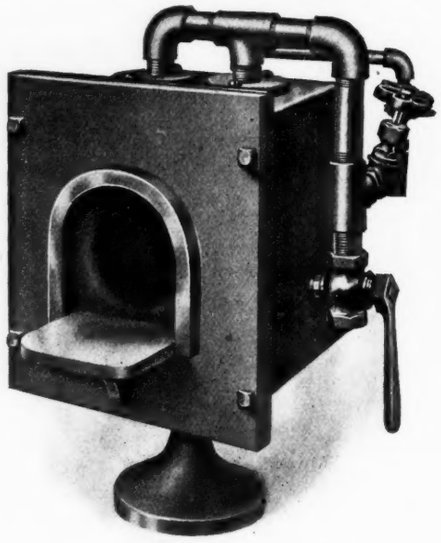


Fig. 2. A Bench Forge for Small Work

Fig. 2 shows a small forge of new construction. It is intended to be placed on a work-bench, where it occupies very little space. The heating space, front and back, has a diameter of 3 inches and a length of 6 inches. It is equipped with a pilot light, which may be left constantly burning at a negligible expense, making it unnecessary to relight the furnace every time it is used. This forge is adapted to hardening

small pieces, heating bars of stock and pipe, light forging, brazing, etc.

The brazing table shown in Fig. 3 is equipped with two blast blow pipes. These have a universal adjustment, allowing them to be placed in any position. This, in combination with the movable bricks, allows the flame to be directed and confined on the work in the most efficient manner. The variety of sizes of the bricks furnished is a convenience in "walling in" the work. The top of the slab stands up 30 inches from the floor. This table is adapted to a wide variety of operations, though intended primarily for brazing. It can be used for hardening or annealing small pieces, heating bars of stock and pipe for bending, and other light work of a similar nature.

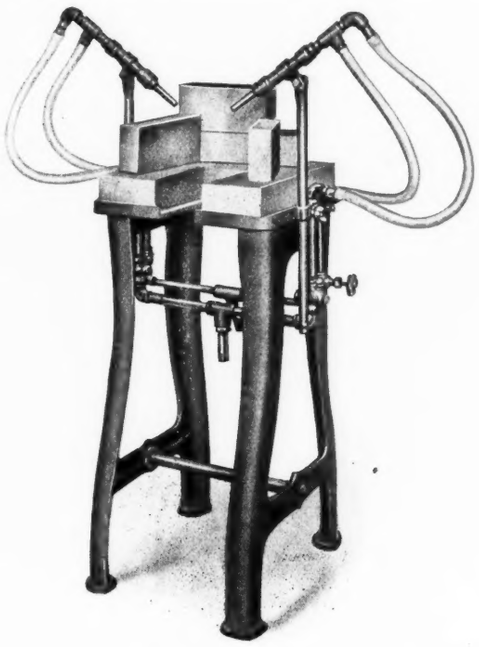


Fig. 3. Brazing Table with Adjustable Blow Pipes

SELLS ROLLER BEARING

The Sells roller bearing herewith illustrated and described is being sold by the Royersford Foundry & Machine Co., of Royersford, Pa. It is the design of Mr. John D. Sells, for many years identified with the "Standard" roller bearing, and is therefore the product of a long experience in this line of work. This bearing is universally adaptable, can be applied to any hanger or pillow-block of corresponding size either for new installations or for substituting in a plant previously equipped with the old style of plain or oil bearings; and it also possesses the advantage, as may be seen from the engraving, Fig. 2, of being applicable without requiring to be pushed on over the length of the shaft from one end to the other.

The construction will, perhaps, best be understood by reference to Fig. 2, which shows the successive operations of putting the bearing in place. First the split sleeve is put on the shaft. This is formed in two parts, with the split running diagonally, as shown, so that the rolls may pass over the joint without shock or irregularity of motion. Next this sleeve is clamped in place onto the shaft by two collars, see *B*, which are provided with counterbores fitting the edges of the sleeve so that they are thus themselves truly located. Next, as shown at *C*, the two halves of the split cage are placed around the sleeve between the collars. Then, as shown at *D*, the box itself is put over the whole and fastened. The application of the bearing will thus be seen to be as simple as the application of a split sleeve or wood pulley.

The bushing is of hardened steel, and absolutely protects the shaft from being cut or scored by the case-hardened steel rollers. Injury from this cause is of common occurrence in other designs. These bushings are so constructed as to vary in thickness, allowing the same size of bearing to be fitted to different diameters of shafts. Each roller cage structure is adapted to three such changes of bushings. This makes it unnecessary for the dealer to carry a large stock of these bearings, as odd-sized bushings will take care of the intermediate sizes.

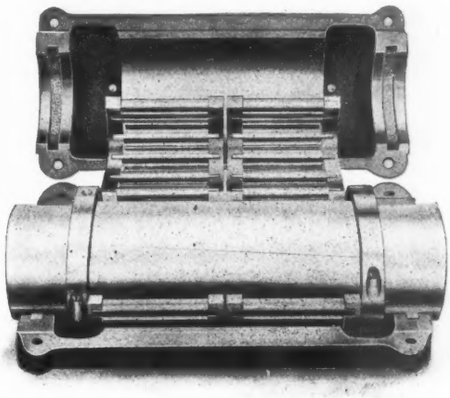


Fig. 1. The Sells Roller Bearing, of the Double Cage Type

The rolls, as plainly shown in Fig. 2, are contained within a roller structure or cage. This separates them from each other, and eliminates the friction caused by the rolls running in contact. It also holds them parallel to each other so that it is impossible for them to get cramped diagonally in the boxes.

This bearing, as may be seen, is of the full floating type, so that none of the customary trouble from end-thrust friction in roller bearings is met with. The two halves of the case are fitted together with milled joints to make them dust-proof, and to give further assurance in this matter a heavy felt wiper is used at each end of the box, which at the same time

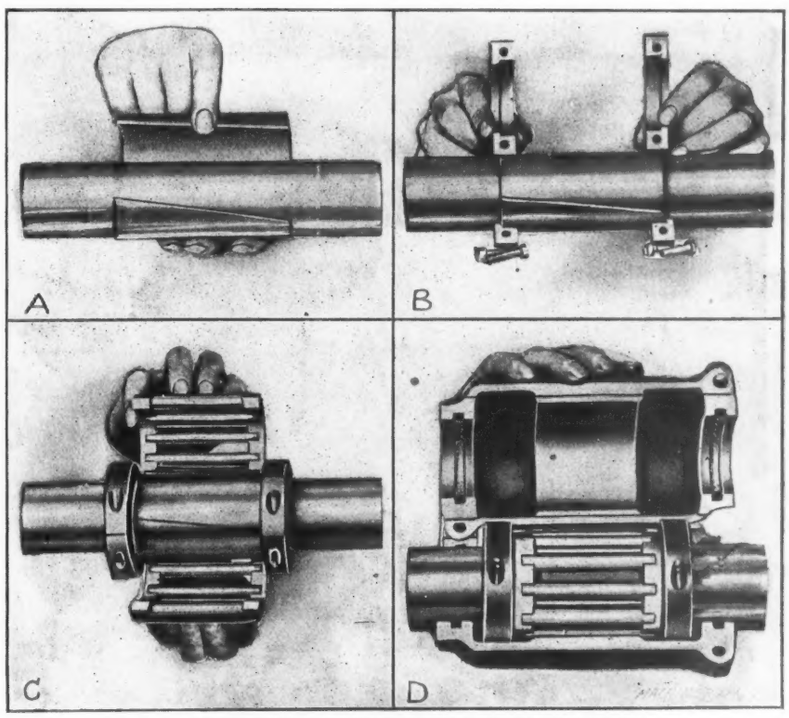


Fig. 2. Assembling a Single Cage Sells Roller Bearing in Place

prevents the loss of oil. Drain holes are also provided so that the case can be flushed with kerosene or other cleansing fluid when the oil gums. Holes are tapped in the top of the box to provide for oil cups. For head- or jack-shaft use, on shafts 3 11/16 inches in diameter or larger, this bearing is provided with a double roller structure as shown in Fig. 1. This gives a greater bearing area for heavily loaded shafts. All parts are made interchangeable. In case any part of the bearing becomes mislaid or broken by accident, it can be easily replaced, avoiding the expense of a new complete bearing.

For the present, at least, the manufacturers intend to sell this form of bearing for fifty per cent less than the price asked for any other similar device on the market.

FERRACUTE TOGGLE PRESS OF UNUSUAL SIZE

The "largest ever built" in the way of various forms of power presses have come along very rapidly in the past two or three years. We are beginning to get familiar with the application of these machines to larger and larger work, and the picture of a new press of unusual size does not, perhaps, excite the same interest that it would have a few years ago. The accompanying illustrations, however, show a double-action drawing press of such enormous size and capacity that the builder, the Ferracute Machine Co., of Bridgeton, N. J., has good reason to call attention to it. This press was built particularly for seamless burial caskets of the largest size, drawn from sheet steel 1/16 inch thick. It is equally well adapted, however, for forming other large drawn work, such as automobile bodies, bath tubs, metallic boats, etc.

The bed is a massive, internally ribbed and trussed casting weighing 18 tons. The width of the bed, right to left, between columns is 9 feet 4 inches and extreme depth of bed front to back, 4 feet 6 inches. Projecting upward from the corners of the bed are round steel columns, 10 inches in diameter, supporting the upper framework, taking the tensile stresses, and also serving as slide-bearings for the outer ram. These columns are connected at the top by heavy stays, the crank-shaft (see *E*, Fig. 2) being journaled in the end stays. The crank-shaft is composed of forged steel, is 15 inches in diameter and weighs 5 tons. Twin gears, each 7 feet 2 inches diameter by 1 foot 6 inches face, are keyed to the ends of the crank-shaft. These gears are steel castings, the teeth being cut. The weight of each gear is 4¼ tons. The back-shaft is driven by a gear at the middle of the shaft instead of at the end, the torsional strains thereby being balanced and the pressures at the end of the shaft equalized.

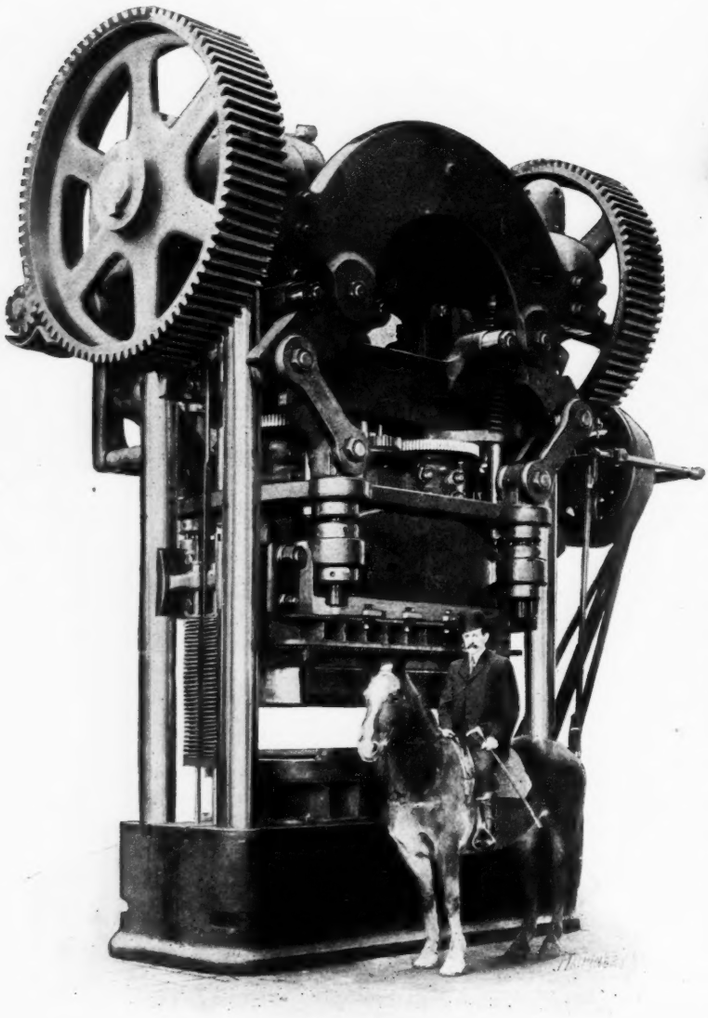


Fig. 1. An Enormous Double-action Drawing Press

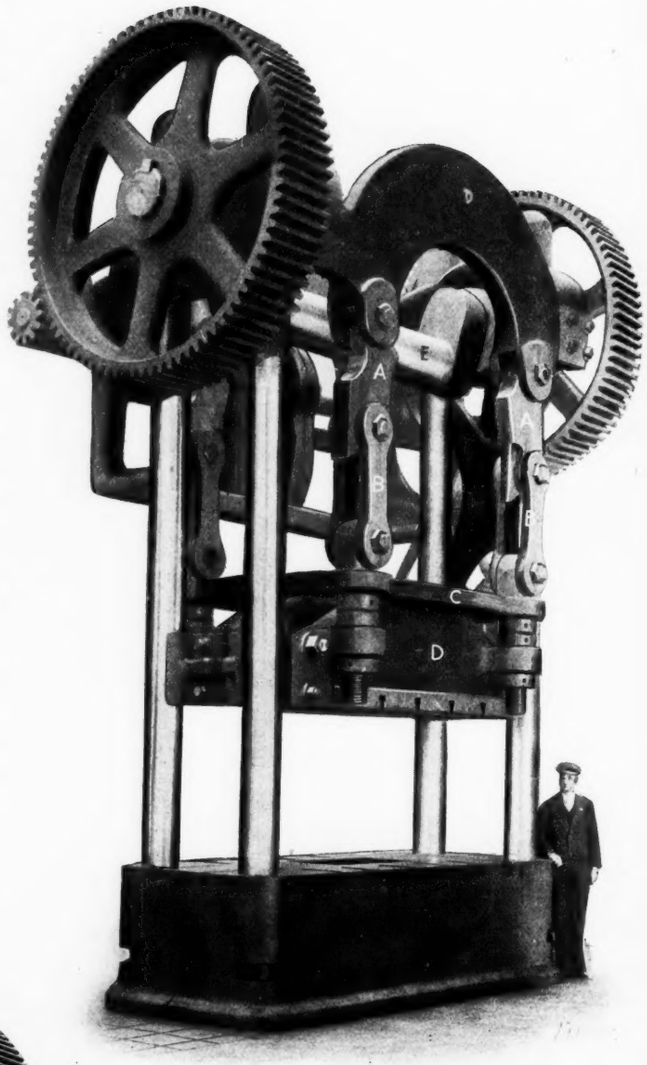


Fig. 2. The Press Partially Erected, showing Cam and Toggle Mechanism for Operating Blank Holder

The upper toggles *A* are pivoted to the front and back frame trusses, the lower toggles *B* being connected to the outer ram or blank-holder *C*. There are four sets of these toggles, giving pressure to the outer ram at four points. The crank-shaft is connected to the inner-ram or plunger by pitman strap and pitman, as usual, there being two bearing points in the plunger.

Rollers on studs projecting from the plunger bear against the upper toggles *A*, causing them to straighten out when the plunger descends, forcing the outer ram down. As the main ram or plunger

rises, after a stroke has been made, similar rollers on the other side of the toggles strike projections at the "knee-joints" of the toggles, causing them to resume their angular position, the outer ram being lifted by steel springs as soon as the toggles are tripped. This is shown in Figs. 1 and 2. The plunger has 32 inches stroke. As the ram has a stroke of 16 inches, it is possible to draw work of very nearly that depth. The adjustment of both ram and plunger is 8 inches.

The fly-wheel is 50 inches diameter and 12 inches face. The press is driven by a 125 H. P. motor through a powerful friction clutch, by means of which the operator has perfect control at all times, being able to start and stop the machine at any part of the stroke. The ratio of gearing is 1 to 300. The press makes about one and a half strokes per minute, giving it a great advantage in speed over hydraulic presses in which heavy work of this character is usually done. A positive knockout is connected to the ram by rods running up through the bed.

The press is 20 feet 2 inches high. It occupies a floor space of 18 feet 9 inches by 9 feet 3 inches. It weighs 100 tons, and gives a ram pressure of 1,500 tons. It was designed by Mr. Oberlin Smith, the president and mechanical engineer of the Ferracute Machine Company.

GARVIN NO. 11/2 GEARED FEED MILLING MACHINE

The milling machine herewith illustrated and described is made by the Garvin Machine Co., Spring & Varick Sts., New York City. The principal features of the design are the box construction of the knee, the arrangement of the knee bearing surfaces and those of the saddle and table, and the compact geared feed mechanism employed. These improvements have been incorporated in a machine which otherwise retains the good points of the older line of millers built by the same firm.

Improvements in the Structural Design

In regard to the general structure of this miller, it may be said that the column is built on the standard lines which have previously given good results in the matter of strength

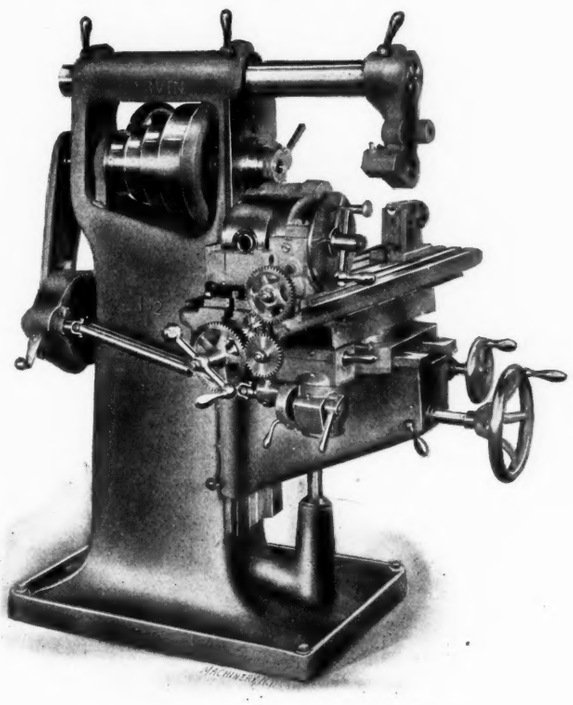


Fig. 1. Garvin No. 11/2 Geared Feed Milling Machine

and rigidity, and consequent output of work. The first point of interest in the structural design relates to the knee, which is illustrated in Fig. 4. This is of the solid top, extended type, which has been patented by the builders. As may be seen, the top is entirely closed except for one very small hole, which does not interfere with strength and stiffness. The back of the knee, where it joins on the column, is also closed, as are the sides and end, while the lower opening is well ribbed. A stiff internal rib is also provided. The bearing on the column is extended upward, and two binders for clamping the vertical adjustment are furnished, with an extra gib screw placed close to each binder.

This solid top construction furnishes the necessary stiffness for resisting the side pressure from heavy cuts, and checks the vibration induced by coarse tooth cutters. These troubles, and a certain amount of distortion due to overhang-

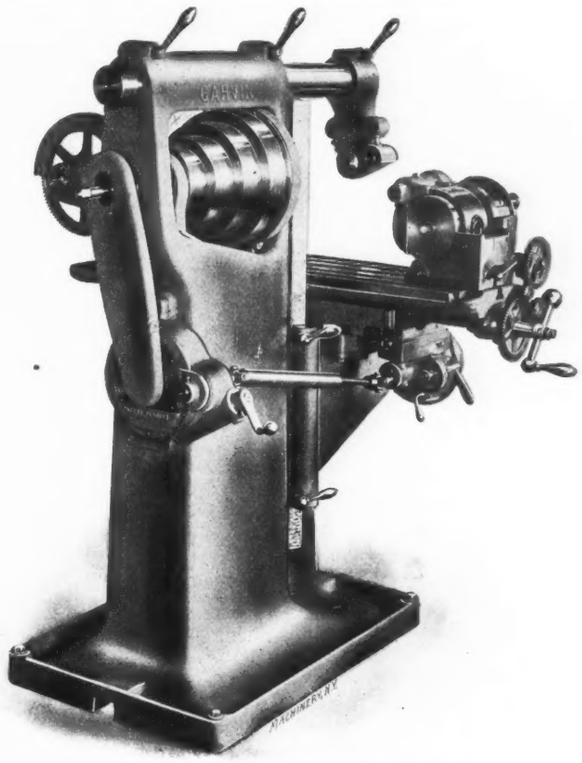


Fig. 2. Rear View of Milling Machine, showing Feed Gear-box and Connections

ing work and table, are liable to be met with in designs which employ an opening in the top of the knee. The opening tends to spring together under stress, permitting the undesirable conditions noted above.

The solid top design is made possible by placing the cross-feed screw just under the edge bearing on the right-hand side of the knee. Any objection which might be offered to this offset control for the in and out movement of the saddle, is answered by the design of bearing employed. This is of a type which has been generally used on gear cutting machines. The saddle is lined up by the narrow bearing on the right-hand side, to which it is confined by a strap gib beneath, which holds it down, and by a tapered gib on the edge. As this narrow guiding surface is practically central with the cross-feed screw, no canting or twisting action is possible, even should the gibs be adjusted very loosely. The resulting conditions are probably better than would be obtained by the usual method of guiding the slide across the full width of the knee, even with the cross-feed nut in the center of this wide guiding surface.

The extended bearing on the face of the column adds greatly to its rigidity, gives a larger and more durable bearing surface, and prevents a tendency to sag; and this, together with the box construction, affords a firmer and more unyielding support to the arm and arbor braces. It also permits giving more clearance between the arm brace and the face of the column without sacrificing the rigidity and accuracy of the structure.

Another interesting point in the design is shown in Fig. 3, which is a view looking down on the top of the saddle, the latter being removed. Particular attention is called to the use for the table bearing of two gibs, tapered in opposite directions. This gives assurance of a good fit at this point, and

consequently of freedom from vibration which would result from the use of a single taper gib worn at one end.

Construction of the Quick-change Feed Mechanism

The new feed-box (shown in detail in Fig. 5, and applied to the millers in Figs. 1 and 2) is unusually compact in construction, when the range and number of feeds it provides is considered. It will give 12 feed changes, varying from 0.002 to 0.080 inch per revolution of the spindle. The construction is best seen in Fig. 5.

A series of gears of different diameters, meshing with each other, is mounted on pivots extending around the periphery of a double-walled circular cage as shown. This train of gears is driven from a central gear mounted on a shaft, which receives its motion from the spindle as seen in Figs. 1 and 2. The cage in which these gears are mounted is provided with worm-wheel teeth on its periphery, meshing with a steep pitch worm mounted on a crankshaft as shown. Each revolution

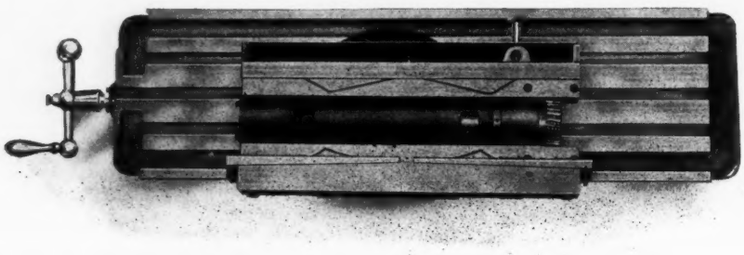


Fig. 3. Top View of Saddle (on Table) showing Double Taper Gibs

of this crankshaft, therefore, turns the cage to a new position; and in each of these positions a new one of the series of gears provided is brought into mesh with a pinion set in a recess in the front of the gear casing. This pinion is connected by the usual telescopic shaft with the feed gearing on the saddle.

Two or three points in the construction of this mechanism should be noted. For one thing, the teeth of the gears about the periphery of the cage, and the teeth of the pinion driving the telescopic shaft, have been given special shapes. This permits them to be turned into and out of engagement freely

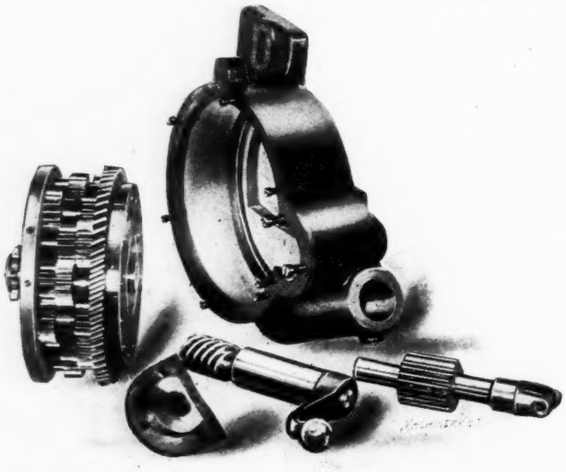


Fig. 5. Feed Gear-box Dismantled to show the Construction

while running at full speed, without any possible danger of interference and consequent injury. Another point that will perhaps occur to the reader as requiring consideration relates to the direction of the rotation of the feeds. The gears in the periphery of the cage, which are brought successively into mesh with the pinion on the telescopic shaft, evidently revolve in different directions. Every other one turns to the right hand, while the remaining ones turn to the left. This means that with every successive feed change, the direction of rotation is altered. This change is rectified by the feed reverse motion in the gear-box on the saddle, to which the telescopic shaft is connected. The small lever shown on this gear-box effects this reversal through a tumbler gear mechanism, similar to that commonly employed in the headstock of the engine lathe.

The compactness of this feed change mechanism is its most salient characteristic. The ease of making the change is another as the crank, for the reasons described, can be turned rapidly and easily without meeting any perceptible resistance, until the desired feed position has been reached. Suitable graduations in connection with an index give direct readings for the rate of feed obtained.

General Features and Dimensions

In its general construction, the remaining features of the machine come up to the standard of requirements in milling

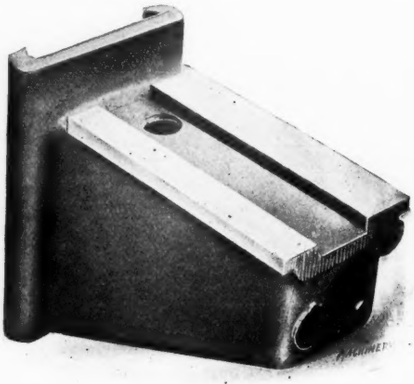
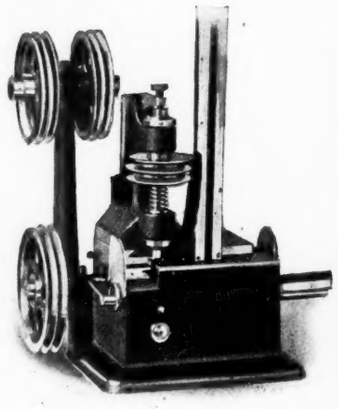


Fig. 4. Solid Top Extended Knee with Confined Guide Bearing for Saddle

machine design. The arm is of solid steel, and overhead braces are provided. The cross, longitudinal and elevating screws are controlled by attached cranks and handwheels which give plenty of room for movement without interference with each other. The main spindle bearing is tapered, and the thrust is taken in either direction by hardened and ground washers on each side of the spindle collar. A soft packing washer is provided which may be taken out and faced off in the lathe to let the spindle in further to take up wear whenever this is necessary. A large cap holds the spindle back to its seat, and thoroughly protects the bearing from oil. The machine has a longitudinal feed of 20 inches, a cross-feed of 7 inches, and a vertical adjustment of 18 inches. The weight packed for domestic shipment is 2,300 pounds.

WALTHAM AUTOMATIC VERTICAL RECESSING MACHINE

The automatic precision machine herewith illustrated is made by the Waltham Machine Works, Newton & Cutter Sts., Waltham, Mass. It was originally intended for recessing watch parts, such as bridges, etc., having a simple recess that can be roughed or finished by a revolving cutter, with the work stationary. It may be used, however, for any similar work on small flat blanks.



An Automatic Precision Recessing Machine

The blanks are placed by hand in the vertical magazine, and all the subsequent operations are automatic. The blanks are taken from the magazine by a slide, operated by compressed air, that carries them, one at a time, to a position underneath the vertical spindle carrying the cutter, where they are securely clamped, also by compressed air. The cutter spindle is then fed to the required depth by a cam attached to a shaft at the rear of the machine.

Upon the return of the cutter spindle, the slide is withdrawn, releasing the recessed blank, but leaving it directly beneath the cutter spindle. From this position it is ejected

by a blast of air with all the chips made by the operation, thus cleaning the clamp for the insertion of a fresh blank. The air valves controlling the operation of the slide, clamp and blast are operated by cams on the same shaft which carries the cam for feeding, recessing and ejecting the blank.

This machine is best adapted for brass work. A production from 12 to 20 per minute can be obtained, according to the size of the recess. The weight of the machine is 80 pounds.

WELLS SPEED LATHE FOR MANUAL TRAINING AND GENERAL SHOP USE

The firm of F. E. Wells & Son Co., of Greenfield, Mass., has developed a line of speed lathes primarily for manual training school use, but which has been found well adapted also to the general run of hand lathe work found in the ordinary machine shop. They are built either as cone pulley or motor-driven machines, and provided either with bench legs or with regular legs for mounting on the floor. The engravings shown herewith illustrate the floor type of machine.

In Fig. 1 is shown the new design of electrically-driven lathe with the motor enclosed in a special headstock. This motor is designed expressly for this lathe, with an extended spindle which is bored out with a No. 2 Morse taper, and threaded on the outside for holding chucks. A ½-inch hole is provided through the spindle for knocking out centers, holding bar stock, etc. The motor has a variable speed control by means of the starting box shown on the front of the lathe.

One of the important new features of this line is the improved spindle bearing furnished. The box is of phosphor-bronze, split, tapered on the outside and provided with nuts at each end for adjustment in the taper seat in the headstock. This allows taking up wear without disturbing the fit on the spindle. An oil chamber in the headstock bearing furnishes

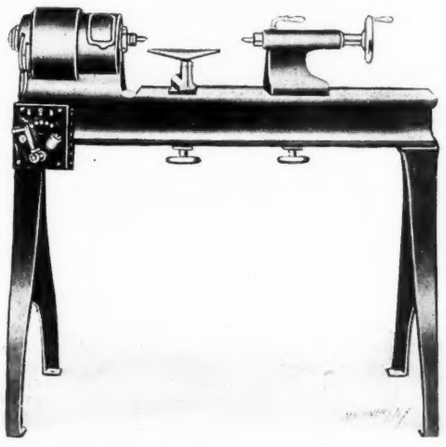


Fig. 1. Speed Lathe with Motor built into Headstock

a constant supply of lubricant to the spindle by means of a ring oiling device of standard construction.

A cone pulley type of this lathe having a novel form of belt drive is shown in Fig. 2. A lineshaft is provided, extending under as many of these lathes as it may be desired to set in a row. On this lineshaft, under each headstock, is mounted a large cone pulley which may be connected with the shaft by means of a friction clutch operated by the hand-lever shown at the end of each lathe. This lever is also connected with a brake, which goes into action when the clutch is thrown off, stopping the spindle instantly and saving considerable time. Suitable guards are provided for both shaft and pulley, obviating any danger of catching the clothing and causing consequent injury to the operator. A flexible coupling is used for connecting the lathes, so that they will run properly even though not set exactly in line. The clutch is made noiseless by hard wood bushings set in the flanges of the coupling. This makes it possible to engage or disengage them without noise while running at any speed.

On these under drive lathes the makers furnish everything except the pulley for driving the shaft, and that will be furnished if desired. Floor hangers may also be provided to extend the shaft for belting to other tools or machines.

Another method of doing away with a countershaft, and the extra belting which it requires, consists in mounting the cone pulley and friction clutch on a lineshaft directly over the lathe. The same friction is used in this case as for the

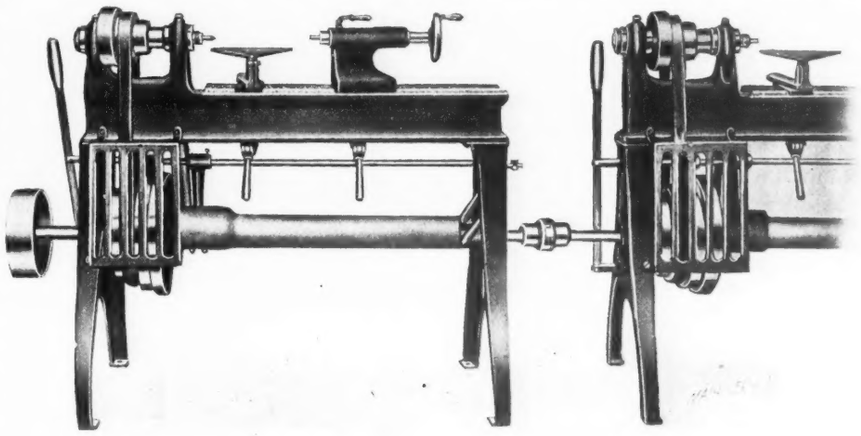


Fig. 2. Under Drive for Speed Lathes, which avoids the Use of Countershafts

under drive. By thus simplifying the overhead work and doing away with belts, countershafts, etc., complication of mechanism is avoided, the time and money spent on maintenance are greatly lessened, and the shop is made much lighter and has a more satisfactory appearance.

The engraving shows the lathe with plain screw feed tailstock, but it will be furnished with combination screw and lever feed if desired. The lathe will also, as stated, be furnished as a bench machine with short legs if preferred by the purchaser.

THE PARKER SPEED-CHANGING DEVICE

The accompanying illustrations shown the application and design of the Parker transmission and speed-changing device. This device is patented by Mr. Clark W. Parker and manufactured by the Parker Transmission and Appliance Co., Springfield, Mass. The transmission can be used for all kinds and sizes of machines that require change of speeds and is particularly applicable to machine tools and automobiles. The speed-changing device is of the non-sliding gear type with positive drive, and can be operated either as a "progressive" or "selective" speed-changing device. It may be made as an integral part of the machine to which it is applied or to take the place of a countershaft, and can be placed in any convenient position. It may be made for any required number of speed changes and any ratio, and of any combination for forward and reverse speeds. In Fig. 1 the device is shown applied to a 16-inch Reed engine lathe. In this case the headcone of the lathe has been removed and a single pulley drive supplied. The transmission takes the place of the discarded countershaft.

The principal parts of which the Parker transmission consists are two cones of gears that are in constant mesh and mounted idly on parallel shafts, the shafts being properly slotted for the sliding keys, and the shock absorber that is applied at the driven end.

The line engraving Fig. 3 shows in the lower part of the illustration a horizontal section in detail and an end view at the driven end. The upper part of Fig. 3 is the plan, and shows the transmission assembled. The lower view shows

the five gears C_1, four for the forward speeds and one for the reverse, which are mounted idly on shaft B_1, and also the sliding key E_1, which is hinged in the sliding sleeve D_1. The key E_1 is shown in its extreme right-hand position, locked in the reverse gear. The reverse is obtained by using an intermediate gear indicated in the end view. The collars between the gears are fastened tightly on the shafts and prevent any tendency that the shafts may have to spread at the slots. They also act as a device to release that portion of the key that is locked in the gear slots when changing the positions of the keys of gears C and C_1 for obtaining the change of speed. The keys are moved by sliding the sleeves D and D_1 on the shafts B and B_1.

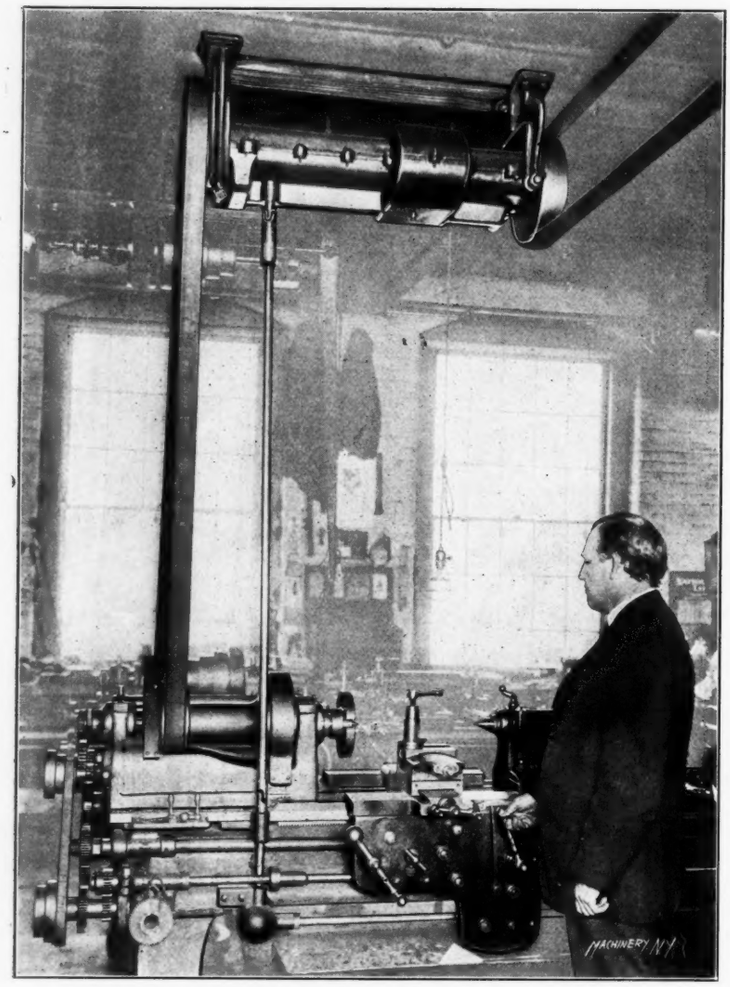


Fig. 1. The Parker Speed-changing Device applied to an Engine Lathe

In the upper view in Fig. 3 are shown assembled both sets of cone gears C and C_1 mounted on their shafts B and B_1, the collars between the gears, the sliding sleeves D and D_1 on each shaft, the yoke F which moves both sleeves D and D_1 and the attached keys. These latter move at the same time when making a change. To the yoke F is attached a rack G which, in this case, is moved by the gear H, that is mounted at the end of the vertical rod passing up from the machine in Fig. 1.

At the right in Fig. 3 is shown the pulley I by which power is delivered to the transmission. This pulley, through the shock absorber J, delivers the power to shaft B, and thence through the gearing and pulley W to the machine to be driven. The gears not locked by the keys are running loose only on their shafts.

The shock absorber is shown in detail in Fig. 2. This is one of the main features of the Parker transmission. It prevents any undue wear and breakage from sudden engagement. The pulley I is fastened to a sleeve K that is a running fit on shaft B. The sleeve K is enlarged at L at which place it is partly cut away. A piece M similar to L is fastened to shaft B. The pieces L and M overlap each other in a clutch-like manner and in the box-like space between them are two wedged-shaped blocks N and a V-shaped block O. The blocks N are forced together by the springs P, and the power is transmitted by block O being wedged in between blocks N. This mechanism is covered by the shell Q that is fastened to the sleeve head L. The helical spring R is at the proper tension to carry the idle load, one end of this spring being fastened to shell Q, and the other end to M. As the springs P force the blocks N together, these in turn hold the block O against its seat in M.

In operation, the shock absorber revolves shaft B only, until the key in this shaft enters the slot in one of the gears C, into which it is forced by small springs indicated in Fig. 3. Now a single pair of gears is revolved until the slot in the meshing gear C_1 comes opposite key E_1, at which time the key is forced into position in C_1 and now, when both keys are engaged, the working load is transferred to spring R which, not being strong enough to take the whole load, shifts it onto the blocks N and O, the block O forcing the blocks N apart until springs P offer resistance enough to permit the carrying of the load. The mechanism is thus engaged without shock or blow.

In Fig. 1 is shown the method of operating the Parker transmission at the lathe carriage. Changing the position of the crank-handle at the lathe carriage revolves the horizontal rod shown, and through bevel gears actuates the vertical rod from the machine to the transmission. At the top of this rod is fastened gear H, Fig. 3, which, in turn, moves the key-shifting mechanism, as mentioned. A pointer and scale near the crank-handle in the apron indicates which pair of gears is engaged. This lathe now has the same speeds that were obtained with the regular head-cone, and the belt is of the same width, but by having better belt contact on the pulleys, the lathe is capable of taking a cut more than double that possible with the cone pulley arrangement. The transmission can also as readily be operated by the ordinary shipper lever arrangement.

The transmission shown has been in constant use for two years. A transmission has also been applied to a six-cylinder Stevens-Duryea 40 H. P. automobile that has run over 16,000 miles. No repairs or adjustments have been made on either of these transmissions, and in a recent examination of the automobile transmission a wear of only 0.005 inch had taken place at the keys. This small wear, of course, in no way impairs the working or efficiency of the transmission.

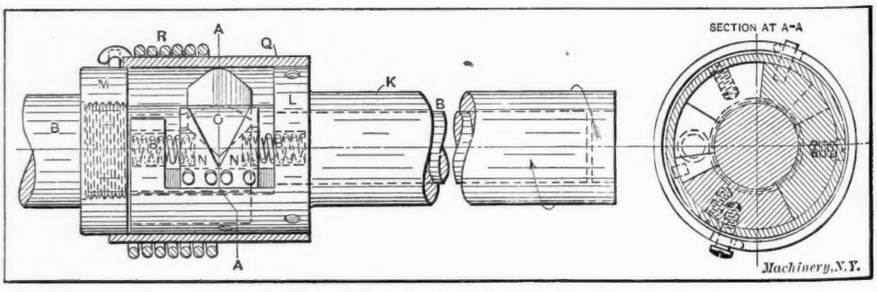


Fig. 2. The Shock Absorbing Mechanism

One of the important features of the device is that it is very compact. The distance between the bearings for a 40-horsepower automobile is only 10 inches. When used as a machine tool drive, the size is, of course, not so important, but its other features will undoubtedly make it of interest to the machine tool trade.

GARVIN SPEED LATHE FITTED WITH AUTOMATIC CHUCK AND TWO-HOLE TURRET

The speed lathe shown herewith was built by the Garvin Machine Co., Spring and Varick Sts., New York City. The simple attachments with which this lathe is provided adapt it to the operations of drilling and tapping, in a way which should produce a surprisingly high output, considering the simple nature of the special devices employed.

As shown in Fig. 1, the headstock is provided with two loose and one tight pulley, together with a belt shifter operated by a treadle, so that the direction of rotation of the spindle can be controlled by the foot, leaving the hands free. This reversal is provided for the tapping operation.

The spindle nose is fitted with a Jacobs chuck, having a leather or canvas faced brake band around it, which can be tightened down on the knurled sleeve by the operation of the lever shown at the front of the headstock. This provision of a brake on the chuck and a reversing mechanism for the spindle, allows the chuck to be opened and closed automatically without stopping the spindle. When this is running forward and the work is inserted between the jaws of the chuck, the tightening of the brake screws these jaws down onto the work. After the spindle has been reversed to back the tap out, the tightening of the brake works in the other direction, releasing the jaws and allowing the work to drop out. This evidently facilitates to a high degree the operation of the machine. A tap holder of the pull-off type is used, so that absolute accuracy in reversal is not necessary.

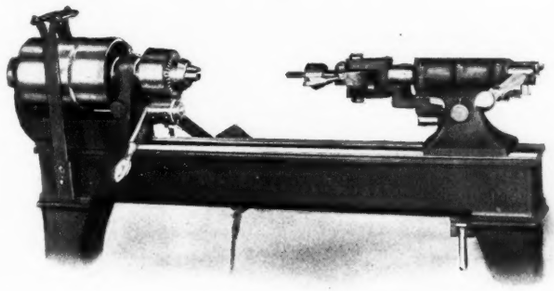


Fig. 1. Automatic Chuck Control and Two-hole Turret, applied to Speed Lathe

A very simple and ingenious mechanism, shown in detail in Fig. 2, is used for operating the two-hole turret, which carries a drill and a tap. This turret, *A*, is pivoted in the forked end *B* of the tailstock spindle. Plunger *C* in the center of this spindle is provided with a point which enters either of the two V-notches shown in the rear edge of the turret, locating it with either one of the two holes in line with the spindle of the lathe.

The turret *A* is alternately thrown from one position to the other by means of the crab-claw shaped piece shown at *D*. This has just thrown the turret to the position shown in the plan view, by the engagement of its rear prong with the kite-shaped dog *F*, which is pinned to the turret. As the tailstock spindle is moved forward, feeding the tool into the work, pin *E* on the lower side of the turret strikes inclined surface *e* of the crab claw, turning it about pivot *G* and bringing the front prong in a position to engage with the front projection of dog *F*. When the turret is again drawn back, this front prong operates on *F* to throw the turret around to bring the other hole in line with the spindle, and it is held in this position by the bearing of spring plunger *C* in the other V-notch. When the turret again moves forward, pin *E* has been shifted to engage with the inclined surface e_1 on the front prong, and the crab-claw is thus thrown back again to the position shown in the engraving.

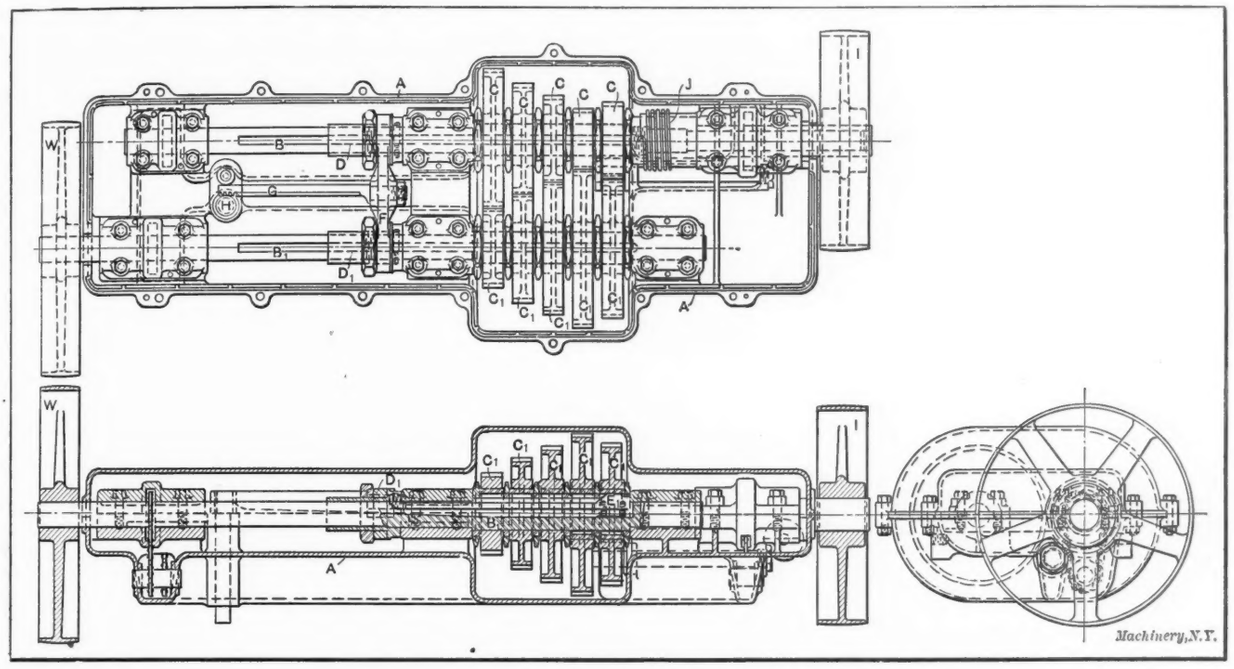


Fig. 3. Section through Speed Changing Device, showing Construction

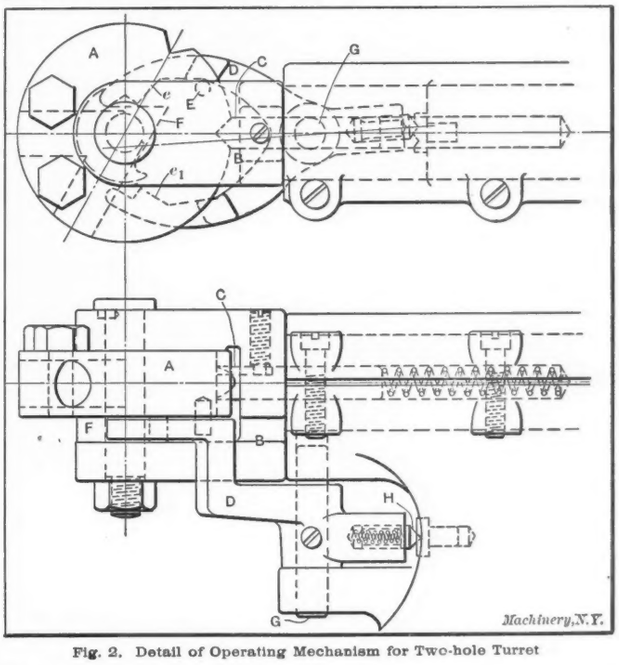


Fig. 2. Detail of Operating Mechanism for Two-hole Turret

Spring plunger *H* enters V-notches cut in the plug shown, and holds *D* in each of its two positions. It will be seen that this can be worked rapidly and without attention, other than is required to make sure that the tailstock lever is thrown clear back at each stroke. The forward movement is limited by an adjustable stop as shown in Fig. 1.

This mechanism is evidently not designed for work requiring extreme accuracy; but in the ordinary case, in which it is simply required to drill and tap a hole, a high output is made possible. The combination of foot and hand lever movements, the automatic changing of tools, and the opening and closing of the chuck, reduce the time required for idle movement to the lowest possible figure.

MIAMI PLAIN AND UNIVERSAL CUTTER AND TOOL GRINDERS

The Miami Valley Machine Tool Co., of Dayton, Ohio, has redesigned its plain and universal tool-room grinders, adding considerably to their convenience. The universal machine is shown in Fig. 1, while the plain machine with the cylindrical grinding attachments, etc., removed, is shown in Fig. 2.

On both the machines the table is traversed by a crank-handle at the front, which operates through a rack and pinion movement. This takes the place of the hand lever arrangement formerly used, gives a more even feed, and is conveniently operated by either hand. On both machines the tables swivel for grinding tapers, graduations being provided at one end for quickly setting to the proper angle. The emery wheel head also swivels, instead of having the body of the machine adjustable as formerly. This gives a quick adjustment, and permits the grinders to be placed in a more restricted space than formerly. This is an item of considerable importance where the floor space is limited. The bearings are of phosphor-bronze, compensated for wear, and protected from grit by felt washers revolving inside the dust ring caps. The machine is designed so that the only time that the vertical adjustment of the wheel spindle is required, is when backing off taper reamers. This vertical adjustment is provided by turning the adjusting nut shown under the base of the wheel-stand in Fig. 3. The universal machine shown in Fig. 1 is provided, as shown, with a live spindle headstock and a spring tailstock for cylindrical grinding. An internal attachment is also permanently mounted on the head, in the position best shown in Fig. 3. When operating the internal attachment, the drive belt on the wheel-head is run as a cross-belt, so that no change is required. The handwheel at the right of the column operates the cross feed, while that at the left gives a fine adjustment to the table movement permitting the accurate squaring up of shoulders, thrust surfaces, etc.

Among the other attachments furnished with this style of machine are, an indexing holder for grinding formed cutters, etc.; a universal holder for angular mills, end mill teeth, etc.,

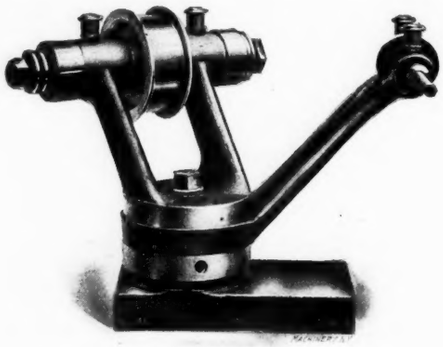


Fig. 3. Wheel Head of Universal Machine showing Vertical Adjustment and Permanently Mounted Internal Grinding Spindle

and a universal chuck, driving dogs, plain centers for reamers and similar work, vise, dead center driving pulley, tooth rests, wrenches, etc. The countershaft provided has a cone pulley driven drum, for belting to the live spindle headstock for cylindrical grinding.

The plain machine shown in Fig. 2 is particularly adapted to cutter and reamer grinding. For this work it is provided, as shown, with a pair of plain centers. Suitable wrenches and tooth rests are also furnished, together with a universal indexing attachment for sharpening formed cutters, end and angular mills, and similar work. In this design of machine, the double countershaft is not required, nor is the fine longitudinal adjustment for the table. In each case stops are provided at the front of the table, as shown, to limit the movement in both directions.

The universal machine will take work between the centers 8 inches in diameter and 16 inches long. The table swivels up to 4 inches taper per foot. Milling cutters, angular or straight, up to 16 inches in diameter can be ground. The internal attachment will operate on holes up to 6 inches in diameter and 4 inches long. The formed cutter centers will take 5 inches diameter up to 11 inches long. The vise has jaws 3 inches long, opening up 2 inches wide. The machine weighs about 500 pounds. The plain machine takes work up to 8 inches in diameter and 20 inches long, but will sharpen milling cutters, angle or straight, up to 16 inches in diameter. The table swivels the same as the universal machine, up to 4 inches taper per foot. This style weighs about 400 pounds.

Fig. 1. Universal Cutter Tool and Cylindrical Grinder for Tool-room Use

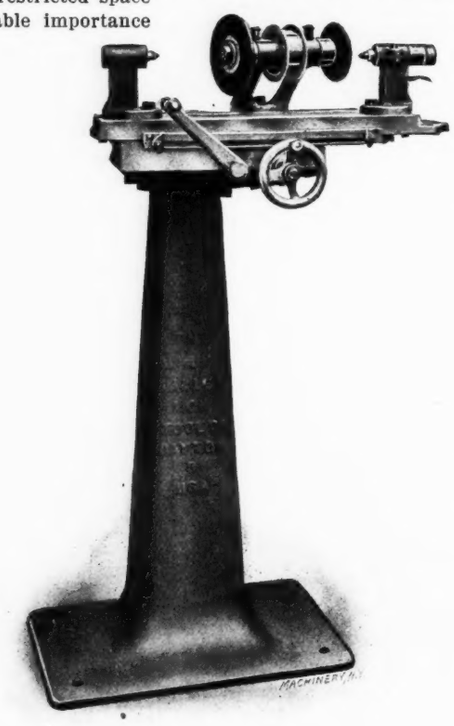


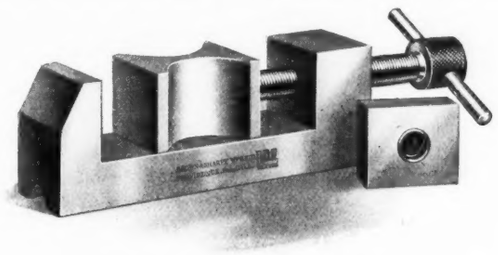
Fig. 2. Plain Machine for Cutter and Reamer Grinding

BROWN & SHARPE TOOLMAKER'S VISE

The device herewith illustrated is a recent addition to the line of small tools made by the Brown & Sharpe Mfg. Co., of Providence, R. I. It is a toolmaker's vise and is intended

particularly for holding work for drilling and other light machining operations, and also for fitting and laying out on the surface plate. Many other uses will readily occur to the user of the tool.

The body is made of steel, drop forged and case-hardened. The screw is hardened to provide against wear. It has a knurled head for easy manipulation, and is provided as well with a short cross-bar through the head, by means of which a firm grip may be had upon the work. Two interchangeable jaws of different size are furnished, which readily slip on and off the end of the screw and provide for holding work of any dimensions up to 2 inches wide. While this vise is light and convenient to handle, it is still made strong



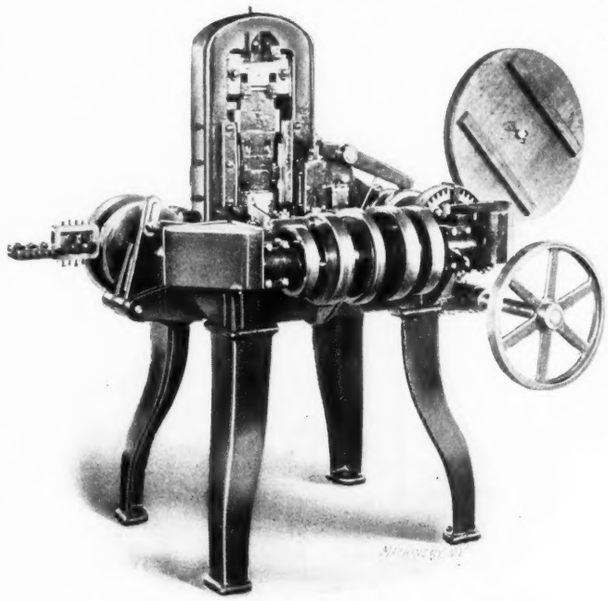
A Toolmaker's Vise for Laying-out, Drilling, etc.

enough to withstand the severest usage it is likely to be subjected to.

The V-groove cut in the under side of the body of the vise makes it useful as a V-block for centering round bars, supporting round work in the drill press, and other operations that an ordinary V-block is used for. The vise can be employed for this purpose by simply turning it over. The V-groove is machined very accurately. This is true of all the surfaces of the vise, whose usefulness is thus extended in laying out and similar careful work, where it is convenient to lay the tool on its side, stand it on end, or place it in other positions without interfering with the accuracy of the setting.

BAIRD WIRE FORMING, FERRULING AND STAMPING MACHINE

In the issue of MACHINERY for January, 1910, we illustrated a machine made by the Baird Machine Co., Oakville, Conn.,



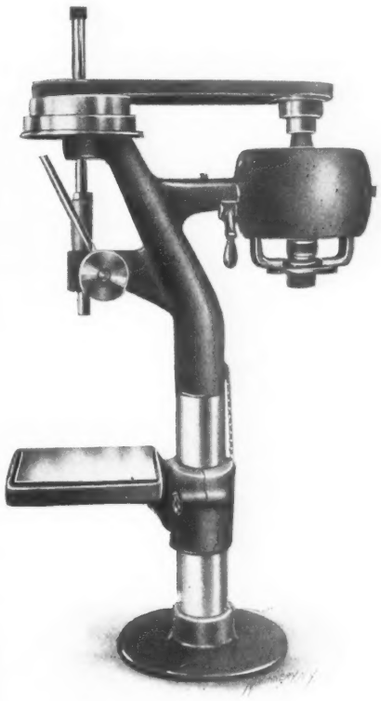
An Automatic Machine for Making Parts from Wire requiring Several Operations

for forming and stamping parts made of wire. In the February, 1910, number was illustrated and described a machine built by the same firm for forming and ferruling wire parts. The machine herewith illustrated combines the functions of the two previously described. It will take wire from the coil, straighten, feed and cut it off, form it into shape, attach to it a ferrule made from a strip of metal wound from the reel at the right of the engraving, and carry it to a press incorporated in the mechanism, where it is flattened and stamped as may be required.

While the machine was first designed to be used particularly on dry goods novelties, it has found many other uses in general manufacturing work. Such articles are made at the rate of 60 to 80 per minute according to size and shape and are dropped from the machine completely finished. It is made in several sizes to cover a wide range of work. The makers state that particular attention is given to the materials and workmanship used, with an idea of making it a serviceable and durable machine.

WILLEY MOTOR-DRIVEN BENCH DRILL

In the department New Machinery and Tools Notes, in the October, 1909, issue of MACHINERY, a brief description was given of a motor-driven sensitive drill built by the Willey Machine Co., Jeffersonville, Ind. This company has now brought out a bench drill built on the same principles as the 12 inch sensitive drill then referred to. The motor is connected to the spindle by a belt and cone pulley, three changes of speed being provided. The motor is adjustably mounted for tightening the belt, and the starting switch is placed within the motor frame, thus eliminating outside connections. Any type of motor can be used, and the motor can be easily detached and exchanged for another of different voltage if required. The table is square and its weight is counterbalanced by a weight inside of the column. When not required it can be swung out of the way. While the tool is very simple and reliable, it is adapted to a wide range of work. The most important dimensions of the machine are as follows: The distance from the center of the spindle to the column is 12 inches. The greatest distance from the spindle to the table is 14 inches. The traverse of the spindle is 3 inches. The power of the motor is 1/3 horsepower, and the weight of the machine, 180 pounds.



Motor-driven Bench Drill made by the Willey Machine Co., Jeffersonville, Ind.

KERN 25-INCH HIGH-SPEED UPRIGHT DRILL

This machine is of an entirely new design and is provided with a number of important improvements in construction. Among these may be mentioned the use of a three-step cone drive with double back-gears, and an improved construction of vertical reverse for tapping and similar operations. A power quick change feed is also provided. In its structural design, and in the proportions of its details as well, it is intended to fully meet the severe requirements imposed by the use of modern high-speed drills.

The three-step cone and double back-gears provide nine changes of spindle speed. This gives a sufficient range for all the work for which the machine should be used, and at the same time gives more power than with the ordinary construction. Wide cone steps of large diameter are possible, giving a greatly increased belt capacity. At the same time,

the belts themselves are always running at a high speed and thus transmit nearly their maximum power even when the spindle is on the slowest speed. This is particularly advantageous in the drilling of large holes where, with the ordinary low ratio single back-gears, a comparatively slow belt speed would have to be used.

The arrangement of the driving gears is best shown in

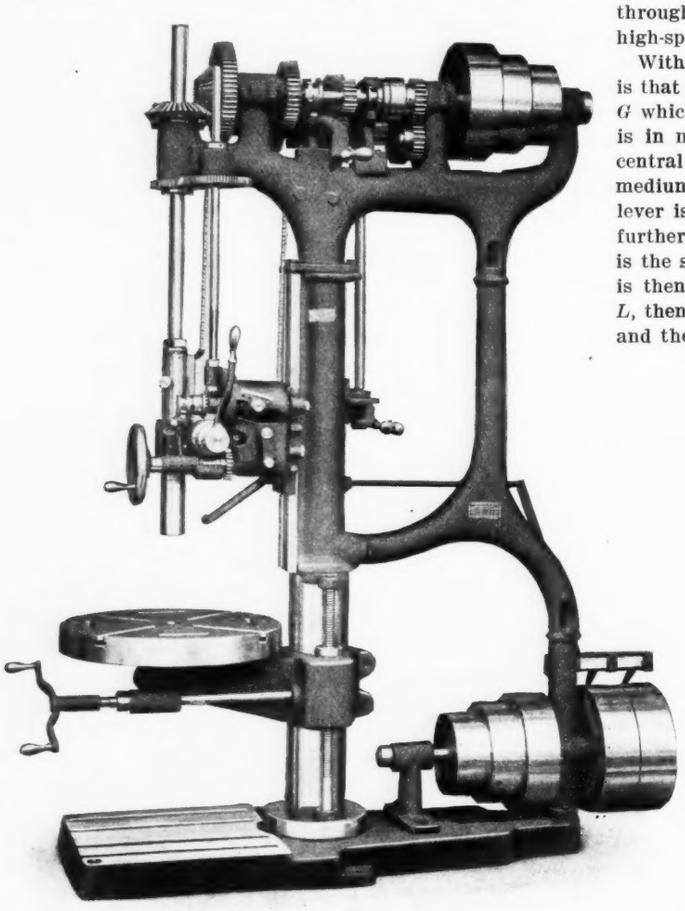


Fig. 1. High-speed Drill Press with Gear Guards Removed

Fig. 3. *A* is the three-step cone pulley, which is belted to the countershaft on the base of the machine. The shaft on which *A* is mounted is bored out to form a bearing for driving shaft *B*, which revolves loosely in it. Keyed to the cone pulley shaft *C* is a gear *D*, which, through idler *E*, is connected with gear *F* on back-gear shaft *G*. Also keyed to shaft *G* is a large gear *H*, meshing with pinion *J*, which is keyed to *B*. The hubs of gears *F* and *D* are provided with friction clutches operated by sliding collars *K* and *L*. These are connected together and operated by the lever which extends down back of the main column of the machine in Fig. 1, and is furnished with a lever in back of the spindle head as shown. This lever is so connected with the clutches that when one is thrown in the other is released.

The mechanism thus described is for reversing the spindle motion, and the lever just described is therefore the one used for tapping. The operation is as follows: When the clutch *L* is thrown in at gear *D*, driving shaft *B* is directly engaged with shaft *C* and runs at the same speed. When clutch *L* is thrown out and *K* is engaged, the motion is from gear *D* through *E* to *F* and then through shaft *G* to gear *H*, which drives pinion *J* at a higher speed and in the opposite direction, for backing out taps, etc. It will be seen that shaft *G*, with this construction, revolves constantly whenever *B* is revolving, but at a slower rate of speed.

The double back-gears are operated by the handle shown at the top of the main column in Fig. 1. This controls sliding gears *M* and *N* and positive clutch *O*, in such a way as to give either a direct drive from shaft *C* through to bevel gear *P*, or else one of two back-gear ratios. When the lever is thrown to the left, clutch *O* engages mating clutch teeth in the face of gear *Q*, which is keyed to the sleeve hub of gear *R*; this being keyed, in turn, to bevel gear *P*, drives the spindle. It will thus be seen that on the forward motion, with clutch *O* thrown in, the drive is direct from pulley *A* through to bevel pinion *P*, without transmitting the power through any gears whatsoever. This is the condition for high-speed work.

With the back-gears arranged in the second position, which is that shown in the engraving, clutch *O* is disengaged. Shaft *G* which, as has been pointed out, revolves constantly when *B* is in motion, has keyed to it sliding gear *M*, which in this central position is in mesh with gear *Q*. By this means a medium back-gear speed is obtained. When the back-gear lever is thrown to the extreme right, gears *M* and *N* are still further shifted until *N* is in engagement with gear *R*. This is the slowest speed, and on the forward direction the motion is then transmitted from pulley *A*, through gear *D* to clutch *L*, thence to shaft *B*, then through gears *J* and *H* to shaft *G*, and then from pinion *N* to gear *R* and bevel pinion *P*.

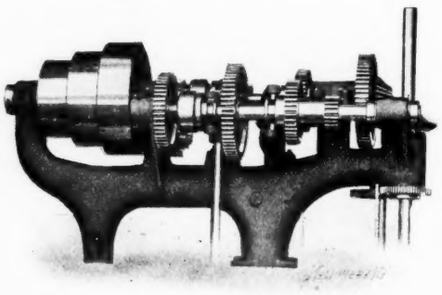


Fig. 2. View of Back and Reverse Gearing

The placing of the friction reverse mechanism between the cone pulley and the back-gears, instead of between the back-gears and the spindle, is unique on the upright drill press so far as we know, although the construction has been common for some time in radial drill press practice. There seems to be fully as much need for it on the upright drill. It gives the great advantage, of course, that on heavy tapping operations in which the highest back-gear ratio is thrown in, the torsional strain is transmitted through the friction at comparatively high speed, and with a correspondingly low torsional strain. With the usual construction, the frictions have to carry the load at low speed and under a greatly increased torsional strain. The frictions are originally designed to be of great strength and durability, and this location gives them an added advantage. The greatest gear ratio between them and the spindle

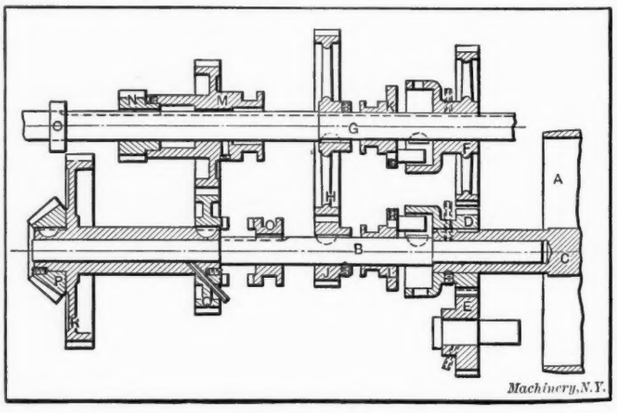
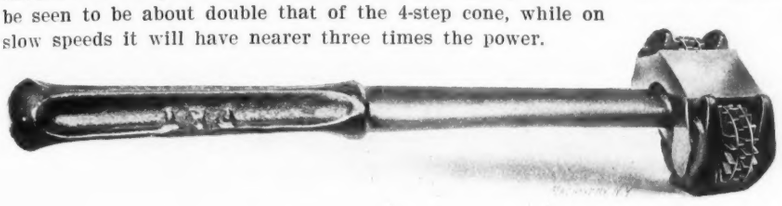


Fig. 3. Arrangement of Gears and Clutches for the Speed Control

is 12½ to 1, in which case they are required to exert less than 1/12 of the actual torque exerted on the spindle. This insures long life, as the possibility of slipping is entirely avoided.

In comparing the driving power of this drill with others of the same size, but of orthodox design, it should be noted that

with this machine the cone diameters are 9, 11 and 13 inches for a 3½-inch belt, with the driving cone running at 440 revolutions per minute. Ordinary proportions for the 4-step cone with single back-gears give cone diameters varying from 5 to 11 inches, with a 2½-inch single ply belt, seldom running over 350 revolutions per minute. Under these two conditions the belt power for the 3-step cone on high speeds will be seen to be about double that of the 4-step cone, while on slow speeds it will have nearer three times the power.



An Emery Wheel Dresser which safeguards the Workman

The operating lever of this reversing or tapping attachment, being mounted directly behind the sliding spindle head, is in a convenient position to be used for starting and stopping the machine, as well as for reversing. When thus stopped, only the the countershaft and the cone pulleys are in motion, thus saving unnecessary wear on the gearing and other revolving parts. On the standard machine without the tapping attachment, this lever operates a single clutch for starting and stopping only. The back-gear changes may be effected if desired while the machine is in operation, though the convenient position of the tapping attachment lever makes it easy to stop the machine for making the change.

The geared feed change mechanism is mounted on the sliding head. It gives eight variations, ranging in geometrical progression from 0.006 to 0.050 inch per revolution of the spindle. It is of simple construction, but seven gears and two levers being required for its operation. A feed plate is attached to the frame in a convenient place, indicating at a glance the correct position of the lever for any desired feed. All the gears are of steel, and have wide faces and coarse pitch. An automatic stop and depth gage for the feed is furnished. These features, in combination with the graduations on the spindle sleeve, permit tripping the feed at any desired depth from any given position within the limits of the travel of the sleeve, allowing any number of holes to be drilled within fixed dimensions. It should be noted that the feed control lever, as well as the other operating levers of the machine, are placed at the right-hand sides where they may be manipulated by the workman without change of position.

The total height of the drill is 89⅜ inches. The column is 6½ inches in diameter, and the spindle 1 9/16 inch. It drills to the center of a 25½-inch circle. The greatest distance from the spindle to the baseplate is 45½ inches, and from the spindle to the table, 32 inches. The spindle has a feed of 10 inches in the head. The table has a vertical adjustment on the column of 15 inches. The spindle is bored to No. 4 Morse taper. This drill requires a floor space of 30 by 70 inches, and has a net weight of 1,900 pounds. For motor drive the cone pulleys may easily be replaced with single pulleys, permitting the speed range to be obtained through the back-gears when using a variable speed motor of commercial design. It should be mentioned that the machine is fully provided with gear guards, though these are shown removed in the illustrations. This drill is made by the Kern Machine Tool Co., Cincinnati, Ohio.

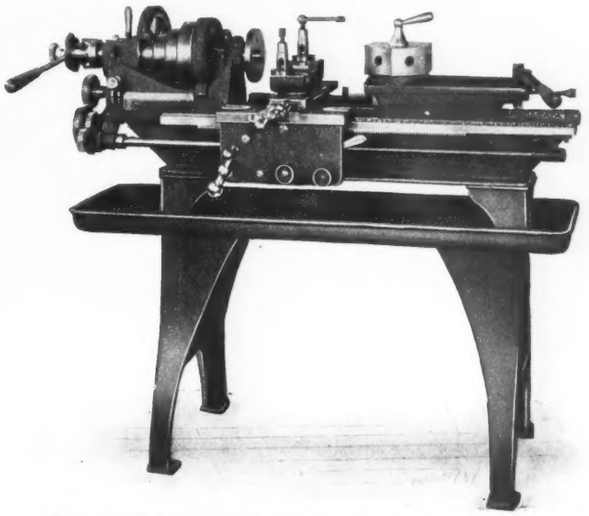
MARBACH EMERY WHEEL DRESSER

The tool herewith illustrated is designed for truing emery wheels, making use for this purpose of the well-known and effective combination of hardened steel star wheels and washers, mounted on pivots so as to revolve freely in contact with the emery surface. The improvement in the construction relates to the provision made for safeguarding the workman from injury in the operation of dressing the face of the wheel. In this operation two dangers are met with, one of which is that of grit getting into the eyes of the operator. If he wears glasses they become so pitted almost immediately that they have to be discarded, owing to the fact that he stands directly in the path of the flying particles and receives them in the face. Besides this there is the further and more serious danger of the breakage of the wheel under the strain of dressing it. This breakage is almost sure to mean injury or even death to the operator, and great expense to the manufacturer.

These dangers are avoided in the dresser shown, simply by providing the tool with a handle extending out to the side of the machine instead of directly in front as usual. This brings the operator out of the line of flying parts of emery or pieces of broken wheel. In order to enable him to exert the proper pressure, horns or projections are provided under the star wheel bearings, which may be hooked under the face of the wheel-rest, permitting him to get a strong leverage by twisting the handle of the tool. Two sets of rolls are provided, as shown, doubling the effective life of the tool. The metal clip spans the ends of both pivots and holds them in place. This permits the rolls to be readily assembled. This tool is made by the F. G. Marbach Co., Medina, Ohio.

ATTACHMENT FOR "STAR" LATHES

In the September, 1909, issue of MACHINERY, the "Star" lathes built by the Seneca Falls Mfg. Co., 330 Water St., Seneca Falls, N. Y., were illustrated and described. It will be remembered that these lathes have 9- and 11-inch swing. In the accompanying illustration is shown one of these lathes provided with three new attachments, lately brought out by the company, which practically convert the lathe into a hand screw machine capable of rapidly producing small duplicate



"Star" Lathe, provided with Turret Attachment, Draw-in Chuck, Rod Feed and Cutting-off and Forming Slide

pieces in large quantities. These three attachments consist of an automatic turret, a draw-in chuck and rod feed attachment, and a double tool-block or cutting-off and forming slide.

The automatic turret, placed on the bed as shown, is operated by a hand lever, and the turret head automatically revolves when the lever draws the slide away from the work. An adjustable stop is provided and the sides of the hexagon turret are finished square with the ways of the bed, so that the face may be drilled and tapped for bolting on special tools, if required. A hole through the turret post permits a bar to pass through the turret head when machining long pieces.

The draw-in chuck and automatic rod feed attachment permits of the feeding and chucking of the bar stock operated upon without stopping the machine. By moving the hand lever operating this attachment to the left, the split collet or chuck is released and the feed fingers are brought back; by moving the lever to the right, the feed fingers are brought to bear on the stock and feed it forward until at the end of the movement the split collet is closed. This device is simple in its construction, but it is very effective and facilitates rapid production to a considerable extent.

The double tool-block or cutting-off and forming slide is attached to the cross slide and is interchangeable with the plain and compound rests. When this tool block is used in connection with the turret and draw-in chuck attachments, the lathe is practically transformed into a complete hand screw machine, being in addition a screw-cutting engine lathe. The machine undoubtedly will be highly appreciated in shops where the requirements do not make a special hand screw machine necessary, but where considerable work for which this machine is adapted is to be done from time to time. These attachments are somewhat of a novelty, and as far as we know, there is no other maker of similar sizes of lathes who furnishes attachments of this kind. Of course, the automatic draw-in chuck and rod feed is similar in principle to that regularly employed by some makers of small hand screw machines on their regular type of tool, but this attachment to so small a screw cutting engine lathe is unusual, and will be appreciated by the users of the machine.

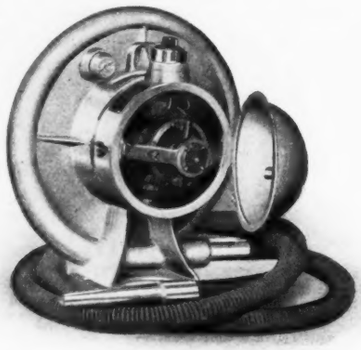


Fig. 1. Sturtevant Electric Dust Blowing Set

STURTEVANT ELECTRIC DUST-BLOWING SET

A dust-blowing set composed of a small light aluminum fan and driven by a direct-connected electric motor, built to operate from lighting circuits, has recently been brought out by the B. F. Sturtevant Co., Hyde Park, Mass. The device with a 1¼-inch diameter flexible reinforced air hose and a 10-inch long polished tapered aluminum nozzle is shown in the accompanying illustration, Fig. 1. The runner or fan-wheel is shown in Fig. 2. It is designed especially for the blowing out of dust from around motors, switchboards or other machinery, and also for the removal of chips and dust in the working of metals. While the blower does not give as high a pressure as would a regular compressed air system, the larger volume of air at the lower pressure in most cases accomplishes the same results without there being the hard severe blast necessary from such a system. The larger volume of air also enables a greater area to be covered in less time than would otherwise be the case. The device is portable, weighing only 55 pounds and provided with socket and cord for attaching it directly to a lamp socket. It can also be used as a vacuum cleaner in cases where a dust-collector is not required. All that is necessary for changing it from a blower to a vacuum cleaner is to attach one end of the hose to the inlet of the fan, and another hose can be connected to the outlet through which the fan may discharge the dust or chips removed. As there is no dust collector, however, used with this arrangement, care should be taken that no objects are picked up which would work injury to the fan.

Fig. 2. Runner of Sturtevant Dust Blower

NICHOLSON DRIVING BLOCK

The device herewith illustrated shows itself on first sight to be a variation of the orthodox form of driving block, which has been in use for many years. The mechanic will readily see, however, that the makers, W. H. Nicholson & Co., Wilkes-barre, Pa., have incorporated several refinements in construction which greatly increase its usefulness.

The driving block is of the type provided with V-shaped center, which supports the work close up to the arbor with any size of hole. The interior of this V has formed in it, as shown, a series of cored slots, in any pair of which may be inserted a shelf for the arbor to drop onto. In driving the mandrel out of the work without the shelf to catch it, it would fall to the floor, instead of having the short drop of an inch or two allowed with this construction. The shelf is of iron, covered with leather, so that there is no danger of bruising the arbor. Of course, the hammer used for knocking out the arbor should be of leather, rawhide, wood or similar soft material. This driving block is 28 inches in height, weighs 225 pounds, and is sold for $15.00.

A Driving Block with Adjustable Shelf for Retaining Arbor

NORTHERN MACHINE WORKS "LITTLE GIANT" CUTTING-OFF SAW

The cutting-off saw shown herewith is intended by its builders, the Northern Machine & Repair Works of Wausau, Wis., to be simple and inexpensive enough to take the place of the power hack-saw, on work for which this latter machine is largely used—namely, the cutting off of stock. The advantage of the circular saw for this work is, of course, the fact that it cuts off the stock squarely, leaving the ends ready for accurate centering. At the same time it permits the stock to be cut to exact length without waste for truing up. A circular saw, when properly driven, also cuts very much faster than the hack-saw.

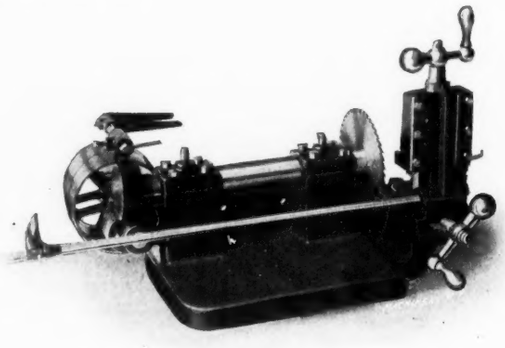


Fig. 1. A Simple and Efficient Cutting-off Saw

As may be seen, the machine has been simplified to the last degree in the point of mechanism; but at the same time, as is shown particularly in Fig. 2, the construction has been made very rigid, so that a cut up to the full capacity of the saw blade can be taken. The power feed, automatic stop, etc., have been eliminated, giving the machine a simplicity which adapts it to the requirements of smaller shops and for use on odd jobs and miscellaneous work in stock-rooms of large plants.

Its use is also suggested by the inventor in key fitting, to lessen the time required to file down and fit the battered ends resulting from driving the key in and out. The key may be made a little longer than the finished size for fitting, permitting the upset ends to be cut off before finally assembling it in the machine. This can be done in much less time than is

required to file these ends down to accuracy. The machine is provided with a vise which will grip either square or round stock, up to 2 inches in width or diameter. The worm drive provided, and the ample belt power, permits it to take a cut

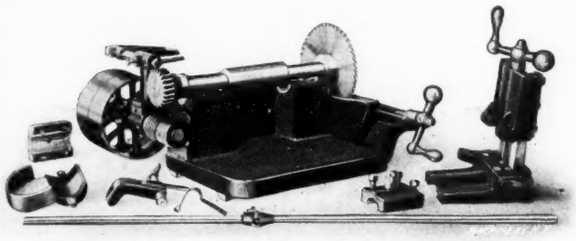


Fig. 2. Machine Dismantled to Show Construction

to its full capacity in two minutes, without crowding the saw. The machine is of simple construction and takes very little floor space. It can be bolted to a post or mounted on a bench.

* * *

NEW MACHINERY AND TOOLS NOTES

HEATING FURNACES FOR DROP FORGINGS, ETC.: Billings & Spencer Co., Hartford, Conn. This is a strongly and durably built line of furnaces, adapted to the use of either oil or gas as fuel. They are intended to be used in heating work for drop forging or other hot working processes.

SMALL INCLINABLE POWER PRESS: T. W. G. Cook, 2 Reade St., New York City. This line of small power presses is built on the inclinable plan, so arranged that the machines may be swung from the vertical clear down to the horizontal, or to any angle in between. The change can be quickly made. The length of the slide has been increased by placing the crankshaft at the back of it, allowing the slide bearings to extend clear to the top of the frame.

HAND-OPERATED COMBINATION SHEAR AND PUNCH: Peck, Stow & Wilcox Co., Southington, Conn. This is a bench machine having separate handles for the shear and punch. The shear blades have a cutting length of 6 inches, and will cut bar iron up to ¼ by 1½ inch, or ½ inch square; it will cut sheet iron as thick as No. 8 gage for the full length of the blades. Holes can be punched to the center of a 10-inch circle, up to ⅜-inch diameter in ⅜-inch iron.

"VULCAN-BIJAW" CHAIN PIPE WRENCH: J. H. Williams & Co., Brooklyn, N. Y. The well-known chain pipe wrench made by this firm is now furnished in a double-ended, modified design, which permits the jaws to be turned end for end. This gives a new, sharp set of teeth for use when the old ones have become worn, doubling the useful life of the tool. The wrench is made in both cable and flat link chain styles, in sizes adapted to pipe and fittings from ⅛ inch to 12 inches.

"TWIN-GRIP" AUTOMOBILE WRENCH: Burkley Supply Co., 27 Old Slip, New York City. This tool is really a collection of four wrenches mounted together in a clamping holder, which permits them to be handled and kept as one tool. Closed, the measurements are 6 inches long by 1¼ inch high over all. The variety of wrenches provided takes in eight sizes of nuts, ranging from ¼ to ⅞ inch; one of the wrenches is furnished with a screw-driver end. The material used is case-hardened steel.

BENCH TAPPING MACHINE: S. A. Stewart Co., Waltham, Mass. This is a vertical machine of light but rigid construction. The spindle pulleys are made of aluminum for the sake of lightness. The reversing is effected by hand lever or treadle, either of which may be used without interfering with the other. The machine will tap to the center of a 12-inch circle, and will take in a maximum height of 7¾ inches from the chuck to the table. It may be used for any tap up to ¾ inch in diameter.

"SPARTAN" CHAIN PIPE WRENCH: Drop Forging Co., West Side Ave. & Fisk St., Jersey City, N. J. This pipe wrench is made of drop forged steel. Both handle and jaws are specially designed to give the maximum degree of strength for the amount of metal used. The teeth are milled at an angle so as to draw the jaws together when the pressure is applied, preventing excessive strain on the bolts, and giving a better gripping action on the pipe or rod to be turned. The wrench is made in five sizes, adapted to pipe from ¼ to 12 inches diameter.

FRICTION TAPPING CHUCK: Woodstock Safety Chuck Co., Woodstock, Ill. This device employs a friction slipping mechanism, which is adjusted to give a driving power adapted to the diameter of tap being used. The adjustment is made by the turning of a knurled nut to agree with graduations provided. The driving power thus furnished is said to be nearly up to the strength of the tap—a point which cannot be reached, however, without the slipping of the driving surfaces. The chuck has a round body without projections of any kind.

RADIAL POWER HAMMER: Radial Power Hammer Co., Los Angeles, Cal. This hammer is especially designed to permit one man alone to perform a wide variety of forging on work which has hitherto required the assistance of a helper. The hammer head is mounted on a swiveling bracket, so that it can be brought over a vise, an anvil or a swage-block. The latter may be rotated to bring various shapes into position beneath the hammer. The head weighs 75 pounds and has a vertical adjustment of 15 inches. It requires 3 horsepower to drive the hammer.

PORTABLE ACETYLENE WELDING APPARATUS: Oxy-Carbi Co., New Haven, Conn. The apparatus made by this firm, which was noticed in the January issue of MACHINERY, has now been put on the market in a portable form. The oxygen and acetylene generators are mounted on a truck, in combination with a reservoir and regulating apparatus for automatically controlling the supply of gases to the nozzle. This outfit is adapted to welding and cutting operations of all kinds by the oxy acetylene process, and is said to be very economical and simple in operation.

PORTABLE STOCK RACKS: American Die & Tool Co., Reading, Pa. This stock rack resembles a type which has been used in various machine tool building firms and has been previously illustrated in the technical papers, but it is now for the first time placed on the market. The racks are formed of a solid casting with wide bases whose shape provides three backs each for lengths of bar stock to rest in. These racks will stand on any floor and do not need to be fastened. Each opening will hold fifteen round bars 2½ inches diameter. The weight of each casting is about 115 pounds.

POWER CHIPPING HAMMER: Coates Clipper Mfg. Co., Worcester, Mass. The makers of the Coates flexible shaft and mongrel gear drive (described in the November, 1909, issue of MACHINERY) have applied this drive to a new portable tool—a power-operated chipping hammer. This is of simple construction, giving 2,000 blows a minute, through the action of revolving hammers on the chisel head. It is operated by a ½ horsepower motor and, it is stated, will perform all classes of chipping work in a manner which competes with the performance of the pneumatic hammer.

CLUTCH PLANER DRIVE: American Twist Drill Co., Laconia, N. H. This firm has devised a friction clutch drive for planers, which is operated by the regular reversing dogs. It obviates the shifting of the belt, which requires considerable power and is a matter of great difficulty, particularly with wide and heavy belts. The wear of the belts due to the shifting is also obviated by the use of this clutch. It is stated to be very positive in its action, causing the platen to come to a stop at very nearly the same point at the end of each stroke. It is designed for application to standard planers.

FOUR-BELT PLANER DRIVE: Niles-Bement-Pond Co., New York City. The difficulty of shifting the wide belts required for heavy planers has led to this new design. The wide forward and reverse driving belts are each replaced by two narrow ones, which have to be shifted but one-half the distance, and which offer considerably less resistance to the movement as well. This gives a greatly increased ease of operation to the planer, and greater surety of action in the automatic reversal of the stroke. There should also be, it would seem, a gain in the reduction of wear and tear on the belts themselves.

LAMINATED LEATHER BELT: American Laminated Belt Co., New York City. This leather belting is built up of strips of leather bound side by side, and so arranged that the cut edge of the leather forms the surface in contact with the pulleys. This construction, it is claimed, gives much greater wearing qualities than when the ordinary construction is used with the fibers of the belt running parallel with the direction of movement. It at the same time brings the wearing surface on a stronger portion of the leather, and one not likely to be affected by improper tanning, or to be burned when the belt slips.

COLD CUTTING-OFF SAW: American Die & Tool Co., Reading, Pa. This is a machine of the type in which the saw is mounted on the carriage and fed in the work. It is spur-gear driven, the gears on the carriage being forged in one piece with their shafts and made of 60 carbon steel. Changes in feed are obtained from a gear box giving a range of from ⅛ to 1 inch movement per minute, all controlled by a single lever. The driving pulley is provided with a clutch, so the machine may be driven direct from the line shaft if desired. An automatic stop is furnished. This machine will take 9-inch round stock. It weighs about 2,200 pounds.

BORING MACHINE FOR LOCOMOTIVE WORK: Niles-Bement-Pond Co., New York City. This tool, made at the Bement Works of the builders, is designed for simultaneously boring and facing both ends of cylinders up to 6 inches in length. The spindle is driven by a gear of large diameter close to its outer end, giving a powerful drive. The work table is 54 inches wide, and 72 inches long in a direction at right angles to the machine. It has a cross-feed of 30 inches and a longitudinal

hand traverse of 18 inches. A 20-horsepower motor is required to drive it. Power handling is provided for the raising and lowering of the table, and the rapid traverse of the bar.

SPECIAL MACHINE FOR MILLING AUTOMOBILE FRONT AXLES: Beaman & Smith Co., Providence, R. I. This machine comprises a long bed on which the work is clamped, and which is also provided with ways on which slide four heads, equipped with suitable cutters for milling the faces of the spring-supporting pads and the bosses for the steering knuckles. Power quick return is applied to all the feed movements, which are so connected as to operate simultaneously. Six feed changes are provided, varying from ½ to 6 inches per minute. A cone pulley gives three speed changes for the spindle, ranging from 17 to 23½ revolutions per minute. Speeds and feeds are all gear-driven.

SWIVEL-JOINT PNEUMATIC HOSE COUPLING: Caskey Valve Co., 99 John St., New York City. This is a coupling for pneumatic hose of the quick connection type; it has the advantage of being provided with a swivel joint, so that all tendency toward kinking in the hose is avoided. The coupling is kept locked by a powerful spring, and it is impossible to open it by jarring. The joints are packed with leather and are tightened by internal air pressure entirely, it not being necessary to jam the surfaces together to insure freedom from leakage. The capacity of this coupling is equal to that of the full area of the hose to which it is attached. They are made for ¼ to 1¼-inch diameters.

HAND-POWER PUNCHING AND SHEARING MACHINES: Little Giant Punch & Shear Co., Sparta, Ill. This firm has recently completed a line of hand-power punch and shearing machines adapted both to actual use in the hand, and, in the larger sizes, for mounting on the bench or floor. They are made both as separate punches and separate shears, and also in combined form; the latter machine is of the floor type and has separate levers for the punch and shear, so that both can be operated simultaneously without interference. This machine will cut round iron up to ½ inch and bar iron up to ¼ by 2½ inches, while the punch has a capacity for 5/16-inch holes in ¼-inch material.

PUNCH PRESSES WITH WESTINGHOUSE MOTOR DRIVE: Toledo Machine & Tool Co., Toledo, O. This firm has recently furnished a complete motor-driven stamping press equipment for making metal boxes, requiring operations like perforating, shearing, blanking, forming, etc., on the various angles, corner braces, sides, bottoms and covers used on steel-bound, wood packing cases. These machines have been equipped throughout with electrical drive, giving a considerable advantage in ease of operation, freedom from countershafts, etc. This results in a clean, well-lighted shop, free from ceiling obstructions. It is stated that the electrical operation has also resulted in a reduction in operating costs.

DRAWING STAND: Shartle Bros. Machine Co. Middletown, O. This is a table of the tripod stand variety, adjustable both for height and angle of the board. It may also be revolved at will to any position required to get a favorable light. A special feature of the construction is a tool shelf, which is so connected with the column by a link arrangement that it is kept horizontal whatever the angle to which the board itself is set. This obviates the accidental dropping of instruments, ink, etc. Special provision is also made for rapidly changing drawing boards. This is a convenience where two or three jobs are kept in hand at one time, as it is unnecessary to remove the paper from the board each time a change of work is made.

TOOL-ROOM AND VERTICAL GRINDER: Blake & Johnson Co., Waterbury, Conn. This grinding stand is provided with a table adjustable for height, and has a tilting adjustment for this table about a pivot, operated by a fine pitch screw and nut, giving an additional fine adjustment for height of 1½ inch. By this means it is possible to use the machine as a surface grinder, sliding the work on the table back and forth under the wheel. This adapts it to the grinding of blanking, stamping and piercing dies, etc. The table is 18½ inches long and 9¼ inches wide. The bracket carrying the table has a vertical adjustment of 6 inches, permitting it to be raised within 3 inches of the spindle center. The spindle boxes are dust-proof.

KELLY SAND BLAST: High Pressure Sand Blast Co., New York City. The difficulty of using high pressures for sand blast work has been principally that of the erosion of the nozzle surfaces by the combined air and sand passing through it at a high velocity. In this apparatus the difficulty has been overcome by leading the sand and the air to the nozzle by separate hose, and providing the nozzle with a removable tip at the orifice. The cost of these tips is insignificant, and they may be quickly renewed as often as needed. Working with 100 pounds pressure, about 70 cubic feet of free air is used per minute. It is stated that the low pressure machines require from three to six times as much sand for the same work as when the higher pressures are used.

"RAPID" SCREW SLOTTING MACHINE: Garvin Machine Co., Spring and Varick Sts., New York City. This screw cutting machine works on a different principle from the orthodox construction, in that the body of the screw is grasped in a split chuck, and fed directly in toward the wheel. The latter is guarded to protect the fingers of the operator, and is equipped with a self-contained reservoir to provide the lubricant. A lever operates the plunger, tightening the chuck when the work is fed toward the saw and loosening the chuck and ejecting the work when the plunger is drawn back again. It will slot screws from ¼ to ½ inch in diameter. Suitable supports are provided for the work-boxes, into the lower one of which the slotted screws fall without help from the operator.

CAM GRINDING ATTACHMENT FOR VERTICAL GRINDER: Pratt & Whitney Co., Hartford, Conn. The well-known vertical grinder made by this firm has been provided with an attachment for grinding automobile cams, particularly those of the type that are formed integrally with the shaft. The flat lower surface of the ring-wheel is used to finish the work. This preserves the constant shape of the cam as the wheel wears down; in this particular it is an improvement over the method of grinding with the periphery of a disk wheel, which gives a changing shape to the work as the diameter decreases. The attachment is easily placed on the machine or removed from it. It is provided with an indexing mechanism for timing the cams. The operating parts are carefully protected from dust and dirt.

NUT CASTELLATING DEVICE: Garvin Machine Co., Spring and Varick Sts., New York City. The screw slotting machine manufactured by this firm may be provided with a simple attachment for castellating nuts. When so used, it is provided with a hexagonal chuck, fitting the work and mounted in a head, which may be rotated by a convenient handle to three different positions for cutting the successive slots. The chuck is self-ejecting, and the machine is provided with all the conveniences found on the regular screw slotting machine. A device acting on similar principles is also made for use in the milling machine. This, however, carries four spindles, and is designed to be used for four saws on the cutter arbor. All four chucks are opened and closed and indexed simultaneously.

DIE AND SURFACE GRINDER: Hemming Bros., New Haven, Conn. This machine is of the vertical spindle, cup-wheel type, which has lately come into extensive use for die sharpening and surface grinding. It is a hand-operated machine, and offers in this respect the particular advantage on certain work of permitting the operator to feel the cut and thus be sure of what the wheel is doing. The spindle is driven through bevel gears and a self-contained countershaft. Rubber wheel guards and a trough surrounding the work-table, keep the cooling water within bounds. The vertical feed handwheel is graduated to thousandths of an inch, on a circle of large enough diameter so that fractions of thousandths can be easily read. This tool will be furnished, if required, with magnetic chuck and automatic feed.

SLOTTING MACHINE: Pottstown Machine Co., Pottstown, Pa. This firm builds a slotting machine of improved construction, giving adjustments which should be particularly useful in tool-making, die work, etc. The slotting head can be swung to an angle and the work-table can be also tilted around to an angle of 45 degrees. This makes it possible to cut miter gears or do similar work. A hole is provided clear through the circular table, the work-slide and the knee, permitting long work to be held without interference. In its general design, the structure of the machine is similar to that of the ordinary column and knee type milling machine, with the cutter spindle replaced by the slotter ram. The distance from the column to the center of the tool is 12 inches. The circular table is 14 inches in diameter and the tilting table has a vertical adjustment of 16 inches.

"PERKINS" COMBINED PROTRACTOR AND LEVEL: Florence Iron Works Co., Florence, Col. This instrument consists essentially of a V-block on which is mounted a disk graduated in degrees and carrying a level; the V-block also carries a prick punch in a central seat. The tool is useful in a number of ways. It is adapted particularly, for instance, to the laying out of keyways on shafting. By means of the level, the V-block may be set on the shafting so that the prick punch point will indicate the vertical center. It is thus possible to locate a line of keys along a shaft having varying diameters. By setting the protractor properly, it is also possible to locate keyways at any desired angle with the horizontal and vertical, clear around to the bottom. It should be useful among other things for quartering locomotive axles, and for laying out eccentric keyways when the angular advance is given.

NEW DESIGNS OF FORGE BLOWERS: Buffalo Forge Co., Buffalo, N. Y. This firm has added two new designs to its line of forge blowers. One of these is intended for use particularly where compressed air is available, and consists simply of a tuyere and jet made on the injector principle. With this construction, a small high-pressure stream of air sets in motion a large volume of air at a low pressure, giving the required condition for the forge fire. The second design is of the rotary fan type, driven by a direct-connected motor. Great care has been taken in this set to have the efficiencies of the motor, the fan and the rotating members in their bearings

all very high, so that the air will be delivered with as little power expense as possible. These sets are made in sizes varying from 1/32 to 1/2 horsepower. They are adapted to direct connection with a lamp socket in shops where electricity is available.

MULTIPLE DRILLING AND TAPPING ATTACHMENT: Rockford Drilling Machine Co., Rockford, Ill. This attachment is applied directly to one of the maker's regular 14-inch drills with tapping attachment, and makes possible the drilling of six holes in a circle simultaneously. It was originally designed for drilling and tapping 54 holes, spaced equi-distantly in a circle about 6 inches in diameter. The drilling of these 54 holes required, therefore, nine indexings of the work, which was effected by the special type of jig used. For tapping, the work was spaced around by hand from one series of holes to the next. The multiple head is clamped directly to the spindle sleeve, and is lined up by guides on the jig base clamped to the table. A spring support is provided which, with the spindle counterbalance, permits the head to return freely after each drilling operation. By the use of this attachment 54 holes, ⅛-inch in diameter are tapped at an average rate of 50 seconds for the set. The drilling operation is, of course, much more quickly performed.

AXLE CUTTING-OFF AND CENTERING LATHE: Fawcus Machine Co., 2820 Smallman St., Pittsburg, Pa. This machine is, of course, a specialized lathe, following the general lines of the machines previously used for this purpose. It has a number of advantages incorporated in its design, particularly in the strength and rigidity of the structure, the power of the drive and the convenience of manipulation provided. Complication of the driving mechanism is avoided by the use of separate motors for the main drive, and for each of the two centering spindles. Each carriage has a centering spindle and a cutting-off tool, and is provided with a quick operating lever for bringing either one or the other into position. The double driving heads are adjustable for length to suit different lengths of axles, although, of course, in ordinary work where the standard gage is employed, this adjustment is not altered. Two rates of driving are provided through friction clutches and simple geared connections, and controlled by a hand lever operated from the front of the bed. These machines were originally designed and furnished for the new axle mill of the Indiana Steel Co., at Gary, Ind.

STEAM TURBINE DRIVEN CENTRIFUGAL BOILER FEED PUMP: De Laval Steam Turbine Co., Trenton, N. J. The development of the centrifugal pump has reached a point which makes it practicable to apply it to boiler feeding. The latest pump designed by the above makers will overcome a head of 700 feet with two stages only, and will give efficiency of over 60 per per cent when working at 1,600 gallons a minute. It can be governed to generate any desired constant pressure, or any desired fixed excess pressure, and it will maintain these conditions without vibration, hammer or shock in the feed line. The advantages of such a pump are numerous. The inflow of water can be regulated at the boiler without reference to the pump. There are no valves and only two packings of small diameter to be kept tight against the hot water. The high efficiency of the design of the propeller has made unnecessary the use of guide vanes, with their mechanical and theoretical disadvantages. Simplicity of construction and accessibility for inspection have been carefully looked out for. The steam turbine driving it can be modified to operate on exhaust or live steam or both as may be required. The pump is, of course, as well adapted to motor drive as to direct connection to steam turbine.

* * *

The famous mine fire in the Greenwood Colliery near the village of Summit Hill in northeastern Pennsylvania, which had been burning for almost exactly fifty-one years has finally been checked. This subterranean fire had resisted all efforts to smother or drown it out and thousands of dollars have been expended in vain efforts to stop its spread (see MACHINERY, October, 1904). It is estimated that $25,000,000 worth of coal has been burned and probably if the last effort had not succeeded, many millions more would have been destroyed. The spread of the fire was checked by building a clay barrier across the basin extending down to the water level. The barrier was approximately 900 feet long and it extended down to a depth of about 220 feet. The work was conducted under great difficulties, the fire being so close at places that the heat and bad ventilation made the work exceedingly arduous. For part of the time the men had to work on half-hour shifts, and work was only possible because of elaborate ventilating apparatus which was installed at heavy cost. Canvas flues were let down into the shaft, which being flexible, could be shifted so as to supply fresh air in the exact spot needed. Fifty thousand cubic yards of clay were required to make the barrier and 8,000 cubic yards of concrete.

ELECTRICAL HEAT STORAGE

A scheme for storing heat generated electrically has been devised by Mr. C. G. Bell, member of the British Institute of Electrical Engineers that may be useful to electric lighting companies in supplying a daylight load. The futility of electric storage batteries for large power stations is generally recognized—Mr. Edison's excepted, of course—and Mr. Bell has tried to solve the problem by converting electricity into heat and storing it for domestic use. Electric heating at regular commercial rates is too costly for all but certain special uses but if a large market for heat could be found in the daylight hours only, a very favorable price could be made by the lighting companies with profit to themselves and satisfaction to customers.

The apparatus in the present form consists of an iron block about eighteen inches high and a foot in diameter. This block is incased in a thick magnesia jacket to prevent radiation. In the center of the block is placed a removable heating unit of several sections. When the current is turned into the heating unit the iron block is raised to a temperature of 600 or 700 degrees F. in a few hours, and will remain heated almost indefinitely, except for what is used. In its original form it was designed for hot water alone. Its present development not only does away with tanks and kettles, but provides hot air, steam, or hot water for heating, with great saving of space, and provides unlimited heat for cooking. Boiling water is instantaneously on tap day or night, even though all the current may be in use at the time for lighting. The system does away with storage of hot water. Instead, an iron coil is cast inside the metal block. As the block is at a normal temperature of 600 degrees, this coil is full of superheated steam. The steam is regulated so that a small or great quantity may be introduced into the water pipe, giving, instantaneously, water at any desired temperature.

The system is to be used with a house feeding device that makes each customer a consumer of a constant quantity of electricity throughout the twenty-four hours of the day. When the current is being used for lighting, fans, or other purposes, it is switched off the heating unit perhaps entirely, and as soon as ordinary uses stop, the current is switched back again into the heater. The advantage of a constant load thus made possible is obvious. It is claimed that it would more than quadruple the efficiency of the machinery in the average lighting power house by making it produce useful current all the time instead of having a large amount of equipment idle save during four or five hours a day.

* * *

EDISON STORAGE BATTERY

The new storage battery which Mr. Thomas A. Edison has been experimenting with for a number of years has recently been subjected to a series of tests to determine its efficiency. In order that the tests might be made under actual working conditions, a special car suitable for street railway service was constructed and in this car the batteries were installed. Two 7½-horsepower motors were used for driving, and a maximum speed of 20 miles an hour was attained. It is stated that this car, which weighs about 5 tons, will run 150 miles at an average speed before the batteries need to be recharged. In outer appearance the cells of this battery do not differ, except in minor details, from the original cell which was brought out in 1901. The structure of the positive plate, however, has been radically modified, and other improvements embodied, to increase the capacity and durability. These batteries are made at present in two sizes. The smaller size gives about 14 watt-hours per pound of cell and the larger size 16 watt-hours. The weight of such a battery for a car requiring an average of 12,000 watts (it being assumed that the battery is to be in service for even five hours without recharging) would be 3,750 pounds. When the additional power required for hauling this dead weight is considered, it is evident that the present system of imparting the electrical energy from the power station to the motors of the street car is not likely to be changed by the present form of this new storage battery.

* * *

CINCINNATI AUTOMOBILE SHOW

The First Annual Automobile Show given under the auspices of the Cincinnati Automobile Club, opened Monday

morning, February 21, with two hundred cars on display representing sixty exhibitors; the floor space given to the machines was 30,400 square feet. Of the cars on exhibition, fifteen were of Cincinnati manufacture, and were made by the Enger Motor Car Co., Haberer & Co., and the Schact Mfg. Co.

Besides automobiles, there were motor-cycles, motor boats, accessories, balloons and aeroplanes. The aero exhibit was strictly local, being furnished entirely by the Holz Balloon Co. of Cincinnati, and consisted of small aeroplane models, a large glider without a motor, and a large, complete, air-inflated balloon model, showing basket, ballast bags, anchor and drag ropes.

Much credit is to be accorded General Manager Ruthford H. Cox, Charles L. Bonifield, Wm. M. Perin and the various committees for placing this show in a class well up towards those of New York and Chicago.

The show closed Saturday, February 26, after a week of continuous success.

* * *

MEMORIAL OF DR. ROBERT H. THURSTON

A beautiful bronze memorial tablet in high relief of Dr. Robbert H. Thurston, one-time head of Sibley College of Engineering, Cornell University, one of the founders of the American Society of Mechanical Engineers and the society's first president, was dedicated in the reception hall of the society at 29 West 39th St., New York, Tuesday evening, February 8. It is a replica of the tablet by Herman H. McNeil, presented to Sibley College by the students and alumni. The tablet bears the inscription:

1839—ROBERT HENRY THURSTON—1903
FIRST PRESIDENT
AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Dr. Thurston was an international authority on the steam engine, thermodynamics, friction and lubrication, materials of construction, etc. He was a voluminous writer, being a frequent contributor to the technical press, the society's proceedings and the author of several standard works. He died October 25, 1903. See MACHINERY, November, 1903, for an account of his life.

* * *

WORCESTER ANNUAL EXHIBITION

The second annual exposition of the mechanical, electrical and textile industries of New England was held in Mechanics Hall, Worcester, Mass., during the week beginning February 7. Two large floors were completely filled with exhibits representing improvements in machinery and appliances in these industries, and the attendance from all over New England was large. It was generally conceded that the exposition was much better than the first one, held last year. Many new machines were shown. It is proposed to continue the exposition as an annual event.

* * *

PERSONALS

Edward Schwartz has been made superintendent of the Toledo Electric Welder Co., Cincinnati, Ohio.

C. G. Heiby, machine shop foreman for the H. Mueller Mfg. Co., Decatur, Ill., has been promoted to the position of tool-room foreman.

R. K. LeBlond, president of the R. K. LeBlond Machine Tool Co., Cincinnati, Ohio, has gone to the West Indies for two months' vacation.

Fred A. Bigelow, formerly New England representative of the Carpenter Steel Co., has been made manager of the company's Cleveland branch.

P. C. Benedict has been made district salesmanager for the Bessemer Gas Engine Co. of Grove City, Pa., with headquarters at 719-721 First National Bank Building, Cincinnati, Ohio.

E. R. Johnson, until recently master mechanic of the Rock Island shops at Horton, Kansas, has been made general foreman of the Illinois Traction System's shop at Decatur, Illinois.

Henry Morris, manager and treasurer of the Western Tool & Mfg. Co., Springfield, Ohio, will sail early in March for a ten weeks' trip to Italy, Germany, France and Great Britain for business and pleasure.

H. E. Obenshain, who has been secretary and treasurer of the Screw Cutting Company of America, Philadelphia, Pa., for some time, resigned February 1 to become president of the Roanoke Iron Works, Inc., Roanoke, Va.

Roy V. Wright, for several years editor-in-chief of the *American Engineer and Railroad Journal*, has joined the editorial staff of the *Railway Age Gazette*. Mr. Wright will supervise the mechanical department of the journal.

E. G. Matter, connected with the office of the National Acme Mfg. Co., Cleveland, Ohio, on Indiana territory, for several years, has been transferred to the Detroit and eastern Michigan territory formerly covered by Mr. W. C. Lang.

James Brown, formerly department foreman for the Cincinnati Milling Machine Co., Cincinnati, Ohio, and later superintendent of the Oesterlein Machine Tool Co., of the same city, has taken the position of superintendent for M. L. Andrew & Co., Cincinnati.

Fr. W. Sebelin, general foreman of the mechanical department of the Cleveland Twist Drill Co., Cleveland, Ohio, has resigned the position to become superintendent of the P. A. Geier Co., Cleveland, general jobbers and manufacturers of automobile parts.

Eph. Smith, who has been the New England sales manager of the Colonial Steel Co. since its organization in 1901, has resigned on account of long continued ill-health. E. P. Fitzgerald, who has represented the Boston office with headquarters at Springfield, Mass., for the past five years, has been appointed successor, the appointment taking effect March 1.

Following the consolidation of *Industrial Engineering* of Pittsburg, Pa., and the *Engineering Digest*, New York, with the title *Industrial Engineering and Engineering Digest*, Mr. Robert Thurston Kent assumed the editorship of the consolidated publication, succeeding Mr. Harwood Frost, who was the founder of the *Engineering Digest*. Mr. Frost has been forced by the pressure of his duties in connection with the *Engineering News* to devote the whole of his time to that publication.

Frank A. Foster, Providence, R. I., will sail from Seattle about March 22 for China where he will take a position as representative of the American Locomotive Co., in which he will have to do largely with machinery and the mechanical parts of railroad work. He requests catalogues and full information regarding products from American manufacturers of machinery. Mr. Foster is a graduate of the Worcester Polytechnic Institute, and his address will be Davenport Road, Tientsin, China, care of Albert C. Lee.

Alfred Spangenberg, Plainfield, N. J., a well-known contributor to MACHINERY, will lecture before the students of the mechanical engineering classes of Columbia University, May 9, on the subject "Assembling in a Manufacturing Line," treating of the following topics: 1.—Elements of Assembling Operations: Definition of assembling, methods and processes of assembling, concrete examples. Assembling a motor-driven planer by two methods with approximate difference in cost. Factors leading to economical production. Machine processes versus hand processes. 2.—Effective Organization in the Assembly Department.

Caleb Rutter, who for the past eleven years was foreman of the machine department of the Pennsylvania Iron Works Co., Eddystone, Pa., has resigned to take charge of one of the tool-rooms of the Autocar Co., Ardmore, Pa. At the noon-hour of February 11, Mr. Rutter was presented with a smoker's case of stering silver, beautifully engraved, by the employees of the works as an evidence of their regard. Mr. A. E. Exton, assistant chief engineer of the plant, who made the presentation, said in part: "There is no doubt that this change means the addition of one more live man to the ranks of the great army of automobile builders."

* * *

OBITUARIES

Fayette Brown, president of the Brown Hoisting Machinery Co., Cleveland, Ohio, died January 20 in his eighty-seventh year.

Freeland Oakley, well-known in his day as an expert builder of water wheels, died in Springfield, Mass., January 17, aged eighty-two years. Mr. Oakley was for years a member of the firm Phelps & Oakley, which built many of the paper mills in Massachusetts. His reputation was made in the construction of large over-shot and under-shot water wheels.

* * *

COMING EVENTS

April 5-7.—Joint convention of the Southern Supply and Machinery Dealers' Association, and American Supply and Machinery Manufacturers Association, Jacksonville, Fla., Seminole Hotel, headquarters. Alvin M. Smith, secretary and treasurer of the Southern Supply and Machinery Dealers Association, Richmond, Va.

April 13-14.—Annual convention of the National Metal Trades Association at the Hotel Astor, New York. Robert Wuest, commissioner, 605 New England Building, Cleveland, Ohio.

April 17-June 1 (April 4 to May 19, O. S.).—International exhibition of internal combustion motors under the auspices of the Imperial Russian Technical Society of St. Petersburg on the premises of the society Panteleimonskaia No. 2. The object of the exhibition is to acquaint the consumer as well as the general public at large with the development and present condition of internal combustion motors, and to show the comparative advantages of each of the existing systems. The exhibit will be divided into sections as follows: Motors for agricultural purposes, motors for artisan in small industries, and domestic use, motors for factories, motors for marine, railway, tram-

car, automobile, aeronautical and similar purposes, motor details and accessories, literature on motors, drawings, diagrams, etc.

May 4-5.—Annual meeting of the Iron and Steel Institute at the Institution of Civil Engineers, London. G. C. Lloyd, secretary, 28 Victoria street, London.

May 10-13.—Seventeenth annual convention of the Air Brake Association, Indianapolis, Ind., Dennisson Hotel, headquarters. An interesting program has been prepared on air brake construction, air pumping, piping inspection and cleaning, triple valves and brake cylinders, recommended practice, etc. F. M. Nellis, secretary, 53 State St., Boston, Mass.

May 14-22.—Prague agricultural exhibit intended to comprise all the leading innovations that have been introduced in agricultural practice, agricultural machinery and mechanical appliances in dairying, etc. Arthur Gobiet, director, Karalinenthal, Prague, Bohemia.

May 31-June 3.—Spring meeting of the American Society of Mechanical Engineers, Atlantic City, N. J.

June 1-August 31.—American Exposition in Berlin, to stimulate trade relations between Germany and America. This will be the first all-American exposition ever held in a foreign country and will be of interest to all Europe as well as America. It will be held during three of the best months of the year for an exposition, being at the full tide of foreign travel, when people will be attracted in large numbers. Max Vieweger, American Manager, 50 Church street, New York.

June 6-10.—Convention and exhibition of the Foundry and Manufacturers' Supply Association, Detroit, Mich., C. E. Hoyt, secretary, Lewis Institute, Chicago, Ill. Cadillac Hotel, Detroit, headquarters of the association convention week.

June 7-9.—Convention of the American Foundrymen's Association and American Brass Founders' Association, Detroit, Mich. Headquarters, Hotel Ponchartrain. Richard Moldenke, secretary. American Foundrymen's Association, Watchung, N. J. W. M. Corse, secretary, American Brass Founders' Association.

June 13-16.—National Gas and Gasoline Engine Trades Association convention at Cincinnati, Ohio, Hotel Sinton, headquarters. Albert Stritmatter, secretary.

June 15-17.—Annual convention Master Car Builders' Association, Atlantic City, N. J. J. W. Taylor, secretary, Old Colony Building, Chicago, Ill.

June 20-22.—Annual convention of the American Railway Master Mechanics' Association, Atlantic City, N. J. J. W. Taylor, secretary, Old Colony Building, Chicago, Ill.

June 23-28.—International Congress of Mining, Metallurgy, Applied Mechanics and Practical Geology at Dusseldorf, Germany. For information apply to G. C. Lloyd, 28 Victoria street, London.

July 26-29.—Joint meeting of the American Society of Mechanical Engineers and the British Institute of Mechanical Engineers in Birmingham and London, England.

SOCIETIES AND COLLEGES

THE CIVIL AND MECHANICAL ENGINEERS' SOCIETY AND SOCIETY OF ENGINEERS have been amalgamated under the name Society of Engineers, Inc. A. S. E. Ackerman, secretary, 17 Victoria Street, Westminster S. W., England.

UNIVERSITY OF KANSAS, Lawrence, Kans., dedicated a new engineering building, February 25. Addresses were made by Frank Warren, dean of the school of engineering; Richard C. Maclaurin, president of the Massachusetts Institute of Technology, and Ernest R. Buckley, president of the American Mining Congress. Chancellor Frank Strong presided.

COLUMBIA UNIVERSITY will present four lectures in the course in works management, by Charles A. Carpenter, March 5, 10, 12 and 17; two lectures by H. L. Gantt, March 31 and April 12; one lecture by Walter N. MacFarland, April 7; three lectures by Harrington Emerson, April 14, 16, 17; three lectures by Richard T. Lingley, April 30, May 5 and 7, and one lecture by Edwin J. Prindle, April 14.

THE SHEFFIELD SCIENTIFIC SCHOOL OF YALE UNIVERSITY, New Haven, Conn., has received a gift of $250,000 for the construction and equipment of the new mechanical engineering laboratory from Mr. George G. Mason of New York, and his brother, Mr. William S. Mason, Evanston, Ill. The new laboratory will have a frontage of about 85 feet and depth of 200 feet. It will be four stories in height, constructed of Indiana limestone and brick. It will contain approximately 50,000 square feet of floor area and 880,000 cubic feet of space. The entire equipment will be new and will consist of the most modern appliances for assisting the students in studying those fundamental principles of applied science which are closely related to mechanical engineering, such as the strength of materials, the combustion of fuel in furnaces and in internal combustion engines, the making of steam in boilers of different types, the using of saturated and superheated steam in engines or steam turbines, the artificial production of cold, the production, transmission and use of compressed air, the pumping of water, transmission of power and the problems of heating and ventilation.

NEW BOOKS AND PAMPHLETS

ENGINEERING STANDARDS COMMITTEE, 28 Victoria St., Westminster. S. W., London. British standard specifications for keys and keyways No. 46. Price 2s, 6d.

BULLETIN OF THE COLLEGE OF ENGINEERING, POLYTECHNIC INSTITUTE OF BROOKLYN. 124 pages, 6 x 8½ inches. Published by the Polytechnic Institute of Brooklyn.

REPORT OF COMMISSION OF EDUCATION FOR THE YEAR ENDING JUNE 30, 1909. VOLUME I. 598 pages, 6 x 9 inches. Published by the United States Bureau of Education, Washington, D. C.

YEAR-BOOK OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, 1910. 365 pages, 6 x 9 inches. Published by the American Institute of Electrical Engineers, 33 West 39th Street, New York City.

BULLETIN OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, containing the president's report for the past year. 140 pages, 6 x 9 inches. Published by the Massachusetts Institute of Technology, Boston.

FOURTEENTH ANNUAL REPORT OF THE INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS, held at Atlantic City, N. J., September, 14-16, 1909. 153 pages, 6 x 9 inches. Frank P. Foster, secretary, Corning, N. Y.

TESTS OF TWO TYPES OF TILE-ROOF FURNACES IN WATER-TUBE BOILER. By J. M. Snodgrass. Bulletin No. 34. 20 pages, 6 x 9 inches. Published by the University of Illinois, Engineering Experiment Station, Urbana, Ill.

THE INFLUENCE OF FORESTS ON CLIMATE AND ON FLOODS. By Willis L. Moore, Chief of the United States Weather Bureau. 38 pages, 6 x 9 inches. Published by the United States Government, Government Printing Office, Washington, D. C.

PROCEEDINGS OF THE ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS, Chattanooga, Tenn., December, 1909. 170 pages, 5½ x 8½ inches. Published by the Association. G. P. Conard, secretary, 24 Park Place, New York City.

STANDARD CODE OF RULES FOR INTERURBAN OPERATION. Adopted by the Transportation and Traffic Association at the 1909 Convention at Denver, Col. 99 pages, 3½ x 6 inches. Published by the Association. Office of the Secretary, 29 W. 39th St., New York City.

STANDARD CODE OF RULES FOR CITY OPERATION. Adopted by the Transportation and Traffic Association, at the 1909 Convention at Denver, Col. 44 pages, 3½ x 6 inches. Published by the Association. Office of the Secretary, 29 W. 39th St., New York City.

COMPARATIVE TESTS OF RUN-OF-MINE AND BRIQUETTED COAL IN LOCOMOTIVE BOILERS; BULLETIN NO. 412. By Walter T. Ray and Henry Kreissenger. 32 pages, 6 x 9 inches. Published by the Department of Interior, United States Geological Survey, Washington, D. C.

THE ESSENTIALS OF LETTERING. By Thomas E. French and Robert Meiklejohn. 72 pages, 9 x 6 inches. 74 illustrations. Published by the Varsity Supply Co., Columbus, Ohio. Price $1.

This book, which is already in its second edition, has been prepared as an introduction to the subject of lettering, and is intended as a manual for students and designers who use lettering either on drawings or in designs of an artistic character. The book contains chapters on the construction of letters, composition of titles, selection of styles, letters in designs, monograms, ciphers and marks, and on drawing for reproduction. That section of the book which is specially intended for the mechanical draftsman contains some very good plates showing the proper proportioning of letters used on drawings, and the chapter on composition should be of value in deciding upon neat looking arrangements for titles on drawings.

MODERN COKING PRACTICE. By T. H. Byrom and J. E. Christopher. 156 pages, 6 x 9 inches. 109 illustrations. Published by the Norman W. Henley & Son, New York City. Price $3.50.

This book contains, with some amplifications, a series of lectures delivered by Mr. J. E. Christopher, at the Wigan Technical College, to a class of men engaged in the working of coke ovens, and it is expected that the book will be as useful to others who are engaged in coke manufacture. There has been in the past too little published on this subject, and to those engaged in this kind of work the book should, therefore, prove of special value. It contains chapters on General Classification of Fuels; Coal Washing; The Sampling and Valuation of Coal, Coke, etc.; the Calorific Power of Coal and Coke; Coke Ovens; Cooling and Condensing Plant, Gas Exhausters; Ammoniacal Liquor; Treatment of Waste Gases from Sulphate Plants; Valuation of Ammonium-sulphate; Recovery of Ammonia from Coke Oven Gases, and Surplus Gases from Coke Ovens.

TEST OF TUNGSTEN LAMPS. Bulletin No. 33, by T. H. Amrine and A. Guell. 33 pages, 6 x 9 inches, 28 diagrams. Published by the University of Illinois, Engineering Experiment Station, Urbana, Illinois.

This bulletin presents the results of tests upon tungsten lamps of 25 watt size. Of the three kinds of lamps tested, one kind was of American manufacture with filaments made by the paste process, the other two being of German manufacture with filaments made by the colloid and deposition process. The tests show that when the lamps are subject to vibrations, the life depends to a great extent upon the style of filament mounting. Filaments mounted under no tension have longer life when subjected to vibrations than those having tightly strung filaments. It was found after burning 2,000 hours under good conditions, that the average candlepower of the filaments made by the paste process decreased to 88 per cent.; by the deposition process, to 89 per cent.; by the colloid process, to 77 per cent. of the initial value.

PATENTS, DESIGNS, AND TRADE MARKS. By Kenneth R. Swan, 386 pages, 5½ x 8½ inches. Published by D. Van Nostrand Co., New York City. Price $2.

This book deals with patents, designs and trade marks from the legal point of view, and being written by an Englishman, it deals in particular with the English law in relation to patents. As, however, American and English law have much in common in this respect, the book will undoubtedly be of value to those Americans who are interested in patent law, and particularly to those who have patent interests in Great Britain. In producing the book, the author has aimed at presenting its contents in such a form as to make it comprehensive to the layman unfamiliar with legal phraseology, and the subject has been handled from a commercial as well as a legal point of view. Two chapters are included touching upon the subject of patent laws in the United States, Germany and France, together with information in tabulated form of the terms, fees, and conditions as to the working of patents, in several of the larger foreign countries.

INTERNAL LUBRICATION OF STEAM ENGINES. By T. C. Thomsen. 97 pages, 5 x 7¼ inches. 24 illustrations. Published by the Technical Publishing Co., Ltd., 55-56 Chancery Lane, W. C., London. Price 2s. 6d.

This book has been written with the end in view of assisting mechanical engineers directly interested in the satisfactory running of steam plants. Designers of steam plants will also find suggestions which will be of value when deciding upon the proper means of applying cylinder lubricants, and the best way of distributing them to the internal surfaces needing the lubrication. Among other things the book treats of the chemical and physical properties of cylinder oils, impurities of cylinder oils, internal lubrication of steam engines, lubrication for engines of different types, including Corliss engines, winding engines, engines using superheated steam, and locomotives, lubrication of valves, and graphite for internal lubrication. The book is of a decidedly practical character, and recommends itself to those who do not wish to go too deeply into the matter of lubrication, but who require a general working knowledge of the subject.

ELEMENTARY COURSE IN PERSPECTIVE. By Sherman M. Turrill. 71 pages, 5 x 7½ inches. 16 Illustrations, printed on inserted folders. Published by D. Van Nostrand Co., New York City. Price $1.25.

In writing this treatise the author has assumed that the student is somewhat familiar with ordinary descriptive geometry, and the book is devoted to illustrating the application of the principles of descriptive geometry to the making of perspective drawings. Two methods for making perspectives are treated, the one intended mainly for the assistance of the mechanical draftsman, and the other for the artist and free-hand draftsman. A large number of problems covering the principles are given throughout the book. The subjects of parallel perspective, angular perspective, perspective of curves and perspective of shadows are dealt with. The mechanical draftsman, in general, is too little informed on the subject of perspective, which, in many cases, would be helpful to illustrate correctly the actual appearance of an object to a non-mechanical person, and the book is recommended to all who are desirous of increasing their knowledge of this method of representing objects.

THE DESIGN OF CONDENSING PLANT. By F. W. Wright. 200 pages, 5 x 7½ inches. 96 illustrations. Published by the Technical Publishing Co., Ltd., 55-56 Chancery Lane, W. C., London. Price 3s. 6d.

This book has been especially written to fill the demand for a book devoted exclusively to the various problems connected with condensing. In the various standard text-books on the steam engine, the references to the subject of condensing are very brief, and a more thorough treatment has therefore been deemed necessary. The several problems met with in the intelligent study of this subject,

such as the transferance of heat from steam to water, the elimination of air leakage, and the withdrawal of air and vapor, etc., have all been dealt with. The book is practical in its character to the extent that it deals with its subject only with reference to practical requirements, but mechanical details of construction have not been considered except in so far as they are necessary for describing the several types of condensers, pumps, cooling towers, etc., required. The book contains chapters on heat units, jet condensers, ejector condensers, surface condensers, design of jet condensers, design of surface condensers, evaporative condensers, water-cooling plants and air pump efficiencies.

MECHANIC'S HANDBOOK. 330 pages, 3⅜ by 5¼ inches. Illustrated. Published by the International Correspondence Schools, Scranton, Pa. Price in cloth binding, 50 cents; in leather binding, $1.

The first edition of this well-known mechanics' handbook was issued in 1893 in the form of a notebook containing 74 pages. It has since passed into the seventh edition and has been greatly improved and enlarged. Its popularity is testified to by the fact that the copy in review is of the 317th thousand. It was the aim of the publishers to present to the public a handbook of convenient size for the pocket, which would contain rules, formulas, tables, etc., in common use by engineers, and it will be generally conceded that this handbook answers the requirements exceedingly well. The contents comprise weights and measures, metric system, specific gravity, elements and alloys, weights of round and square rolled iron, weights of cast iron pipe, logarithms, trigonometrical functions, prime numbers, circumferences and areas of circles, use of formulas, tables of powers and roots and reciprocals, mensuration, formulas for mechanics, rules for belting, pumps, hydro-mechanics, strength of materials, boiler design, care of boilers, chimneys, machine design, change gears, screw cutting, steam engineering, machine details, rope belting, wire rope, definition of electrical units, wiring and wiring diagrams, wire tables, underwriters' rules, dynamo and motor design, batteries, electric and gas lighting, cable testing, surveying, laying out railway curves, leveling, tables of radii and curves, retaining walls, tunnels, earthworks, etc.

DESIGN AND CONSTRUCTION OF INTERNAL COMBUSTION ENGINES. By Hugo Güldner. Translated from the second revised edition with additions on American engines by H. Diederichs. 672 pages, 9 x 11 inches. 728 illustrations in the text and 26 folding plates. Published by the D. Van Nostrand Co., New York City. Price, $10.

This book presents without doubt the most complete treatment of the subject of gas and oil engines that has as yet been published. It goes thoroughly into both the theory and practice of the design of gas engines and auxiliaries. No effort has apparently been spared in making the information as complete as possible, and several colored folding charts are included, showing with great clearness the arrangement of complete gas engine installations. It is not possible in a short review to give full credit to the work, but it should be mentioned that the aim of the book is to clear the ground for placing the internal combustion engine among the machines whose design can be worked out on a thoroughly scientific basis, rather than along experimental lines. The work is founded on practical experience gathered during fifteen years in an executive capacity. Being thus written by a gas engine designer and builder, it presents to the gas engine designer a useful practical guide which is not merely descriptive of what has been done, but which analyzes the problems underlying the design of gas engines and points out the necessary requirements and the path to follow. Besides the numerous illustrations in the text, the book contains twenty-six folding plates, practically all of which illustrate existing installations of gas engines or sections and plan views of actually built successful gas engine types. Besides, there are 151 tables of data both of theoretical and practical value to the designer, ranging all the way from tables in thermodynamics, necessary for a successful design along scientific lines, down to the practical everyday shop tables required by the designer when making his drawings for the shop. The book is divided into four specific parts. Part I treats of the various methods of operating gas engines, and the gas engine cycles. Part II deals with the design and construction of internal combustion engines, and treats specifically of each part of the machine, such as the beds and frames, cylinders and jackets, cylinder heads, stuffing boxes, pistons, piston rings, piston rods, crankshafts, connecting-rods, valves, valve gearing, fly-wheels, governors and ignition apparatus. All the auxiliaries of gas power installations, such as gas producers, starting apparatus, mufflers, cooling arrangement, piping, pressure regulators and general machine parts, including screws, studs, keys, gas pipes, pipe fittings and flanges, and helical springs, are also treated. Part III deals with the construction, erection and testing of modern internal combustion engines. In this case each of the various types of gas engines in common use as manufactured by various firms are dealt with specifically. Part IV deals with gas engine fuels and the combustion in gas engines. Finally a voluminous appendix is added, giving the theory of thermodynamics and the fundamental principles of thermo-chemistry, together with details from practice, giving directions for operation, attendance, etc. To anyone who wishes to study the subject of gas engines thoroughly, or who requires a reference book on the subject which deals authoritatively with all the phases of gas engine theory, design and intallation, this book can certainly be recommended as the most complete work on this subject available.

CATALOGUES AND CIRCULARS

GENERAL ELECTRIC COMPANY, Schenectady, N. Y. Bulletin No. 4689 on ornamental street lighting.

H. W. JOHNS-MANVILLE CO., 100 William St., New York. Circular of insulating coverings for steam pipes and boilers.

GISHOLT MACHINE COMPANY, Madison, Wis. Leaflet illustrating construction of friction headstock and lever control of Gisholt vertical boring mill.

MANHATTAN ELECTRICAL SUPPLY COMPANY, 17 Park Place, New York. Catalogue of electrical supplies entitled, "Something Electrical for Everybody."

HARRIMAN ENGINEERING COMPANY, 53 State street, Boston, Mass. Catalogue of Harriman rotary steam engine, rotary gas engine, and rotary compressor and pump.

ADAMS-BAGNALL ELECTRIC COMPANY, Cleveland, Ohio. Bulletin No. 85 superseding Bulletin No. 79, descriptive of Adams-Bagnall regenerative flame electric lamps.

E. G. SMITH COMPANY, Columbia, Pa. Folder containing testimonials of users of Columbia calipers. It states that over 50,000 Columbia calipers are now in use.

NATIONAL MACHINERY COMPANY, Tiffin, Ohio. Circular of National interchangeable case threading dies illustrating construction, method of grinding and the National die sharpener.

NORTH WESTERN EXPANDED METAL COMPANY, 930-950 Old Colony Building, Chicago, Ill. Bulletin of data on concrete reinforced with expanded metal as used in sewers, tanks and walls.

WAGNER ELECTRIC & MFG. CO., St. Louis, Mo. Circular illustrating the Wagner motors applied to ventilating fans, ice cream freezers, bread mixers, coffee grinders, pumping organ blowers, etc.

BOULET'S FINE TOOL WORKS, Beverly, Mass. Circular of Boulet's improved universal micrometer test indicator, and measuring instrument which, within its range, is as accurate as a micrometer caliper.

WILLIAMS TOOL COMPANY, Erie, Pa. Copy of report of results of four tests conducted by the Westinghouse Machine Company, Pittsburg, Pa., of Riblet heaters for utilizing exhaust heat of gas engines.

GREENE-TWEED & CO., 109 Duane street, New York. Advertising card of M. Covel belt fasteners, made in six sizes. These cheap and efficient belt fasteners are made of specially tempered steel wire that clinches without breaking.

B. F. STURTEVANT COMPANY, Hyde Park, Mass. Circular of Sturtevant ready-to-run ventilating sets for small and general offices, reception rooms, telephone booths, toilet rooms, sleeping rooms, kitchens, basements, laboratories, engine rooms, etc.

BARBER-COLEMAN COMPANY, Rockford, Ill. Catalogue A of high-speed steel and carbon steel milling cutters, spur gear and worm gear hobs, gear cutters and form cutters. Special cutters of all descriptions are made to order by the company.

TERRELL'S EQUIPMENT COMPANY, Grand Rapids, Mich. Circular on metal lockers for factories, foundries, shops, clubs, schools, gymnasiums, hotels and hospitals. These lockers are made in a variety of styles suitable for the uses mentioned.

LEBANON STEEL CASTING CO., Lebanon, Pa. Folder illustrating steel castings for automobiles. The characteristics claimed for Lebanon steel castings are efficiency, toughness, truth to pattern, freedom from blow-holes and smoothness of finish.

SPRAGUE ELECTRIC COMPANY, 527-531 West Thirty-fourth street, New York. Reprint of article in the *Iron Age* entitled, "Handling Coal by Electric Shovels," being an article descriptive of installations of Sprague Electric Company apparatus.

C. W. LEAVITT & CO., 30 Church street, New York. Reprint of paper by Mr. Wilhelm Borchers, read before the Pittsburg meeting of the American Institute of Mining Engineers, February, 1909, on Girod electric furnaces and the Girod steel process.

GOLDSCHMIDT-THERMIT COMPANY, 90 West street, New York. Bulletin on repairing steel and iron rolls by the thermit process, illustrating the fractured rolls, the mold, the wax pattern in position, the apparatus ready for making the weld and the finished weld.

CUSHMAN CHUCK COMPANY, Hartford, Conn. Condensed catalogue and price list for 1910 of Cushman chucks and face-plate jaws. Cushman chucks are made in a large variety of styles and sizes adapted to all classes of machine work and general manufacturing.

GENERAL ELECTRIC COMPANY, Schenectady, N. Y. Booklet on building lighting with General Electric tungsten and tantalum lamps, illustrated with views of public buildings in New York, sky-scrapers, stores, and other large buildings in New York and other cities.

WABASH GEAR WORKS, Terre Haute, Ind. Catalogue of transmission levers and cone clutches for automobiles. The gears and shafts are made from special gear steel forgings which are subjected to approved heat treatment. The shafts are mounted on roll or annular ball bearings.

GARVIN MACHINE COMPANY, Spring and Varick streets, New York. Catalogue E of screw machines, monitor or chucking lathes, automatic chucks (stop and open types), screw head shaving machine, double turret screw machines, screw machine tools and attachments. Descriptions are in English, German and French.

INTERNATIONAL EXHIBITION OF RAILWAYS AND LAND TRANSPORT, Buenos Ayres, Argentine Republic. Circular No. 17, giving list of foreign committees and commissaries, statistics of foreign commerce of Argentine Republic and other information of interest to manufacturers contemplating exhibiting products at the centenary.

GARVIN MACHINE COMPANY, Spring and Varick streets, New York. Catalogue C on universal and plain milling machines, constant drive universal and plain milling machines, hand milling machines, vertical milling machines, motor-driven milling machines, universal cutter and tool grinder, die slotting machine and milling machine tools.

TERMINAL ENGINEERING COMPANY, 30 Church street, New York. Circular of Burdon's oil-gas furnaces of portable or stationary types. The Burdon furnace operates with a Bunsen flame, produced by gas derived from crude oils, and is said to be absolutely smokeless. It is designed for heating rivets, nails, drop forgings, tubes, bolts, spikes, etc.

CHARLES T. MAIN, Boston, Mass. Copy of booklet entitled, "Approximate Cost of Mill Building," containing valuable data and information on mill building construction. Although fundamentally it refers to textile mills, its application is broad enough to establish fundamental facts regarding manufacturing buildings in the iron-working industries.

B. F. STURTEVANT COMPANY, Hyde Park, Mass. Bulletin No. 173 on the Sturtevant electric dust blowing set designed for blowing out dust from around motors, switchboards, textile machinery, type cases, and other places difficult to get at or dangerous to handle. The apparatus may also be used as a suction cleaner where a dust collector is not desired.

GARVIN MACHINE COMPANY, Spring and Varick streets, New York. Catalogue B of Lincoln and duplex milling machines and profiling machines, vertical spindle milling machines, universal cutter and tool grinder, vertical horizontal and automatic drilling machines, duplex drill lathes, gang drills, etc. The descriptions are in English, German and French.

PAWTUCKET TOOL COMPANY, Pawtucket, R. I. Circular of friction tapping chucks, which may be used to drill and tap holes, and set studs therein without change. The friction may be adjusted to suit the tap, thus insuring against breakages. It is made in two sizes: No. 0 will handle taps up to ⅜-inch diameter, and No. 1 from ⅜ to ¾-inch diameter.

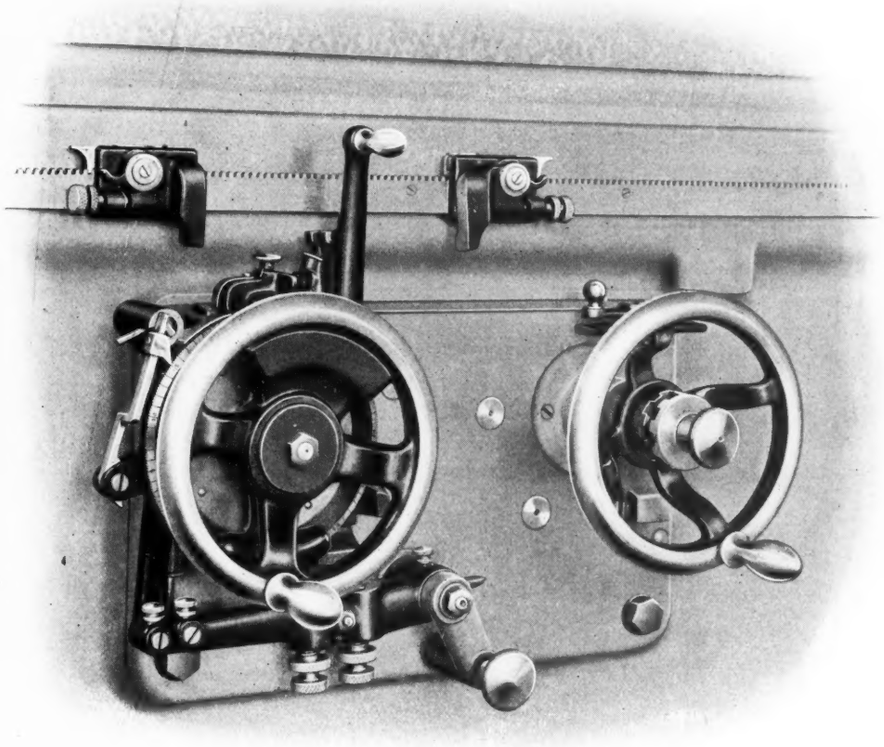
INTERNATIONAL CORRESPONDENCE SCHOOLS, Scranton, Pa. Reprint of editorial in *Colliers' Weekly* on teaching by correspondence. The editorial resulted from the personal investigation of Mr. Mark Sullivan, who found that the correspondence schools and the International Correspondence Schools in particular are doing a great work in the education of students in the arts and trades.

SWEDISH CHAMBER OF COMMERCE, New York. Bulletin containing, besides some general information regarding trade conditions in Sweden at the present time, a list of goods offered by Swedish firms in the United States, of American goods offered in Sweden, and of Swedish goods asked for by buyers in the United States. A short review of the extent of the Swedish iron industry in 1909 is given.

CARBORUNDUM CO., Niagara Falls, New York. Copy of "Revised American Statesman Series" entitled: "George Washington," by F. W. Haskell, president of the company. This number of the series is another of Mr. Haskell's satirical efforts which have attracted so much attention from those favored with copies. Copies of the Revised American Statesman series will be sent to any address upon application.

GENERAL ELECTRIC COMPANY, Schenectady, N. Y. Bulletin No. 4715 superseding Bulletin No. 4693 on General Electric No. 210 railway motor. This is a 70-horse-power, 600 volt motor of substantial construction, having brush holder and field coil supports, and is practically sparkless even under heavy over-load. The bulletin gives detailed description and contains speed table, characteristic curves and dimension diagrams.

Increase in production and decrease in cost of operation are made possible in grinding machines by a well designed and accurately controlled automatic cross-feed mechanism.



B. &. S. Grinding Machines Embody These Features:

The feed is set for any desired size by pressing the thumb latch. It can be set to feed the full amount at both ends of the table travel or it can be set to give any part of the full amount at either end. When the work reaches the size for which the mechanism is set, the cross-feed is automatically thrown out. It is particularly advantageous when a large number of pieces are to be ground accurately to size.

Send for booklet giving other details of the machine.

BROWN & SHARPE MFG. CO.

PROVIDENCE, R. I., U. S. A.

CUTLER-HAMMER MANUFACTURING COMPANY, Milwaukee, Wis. Booklet on elevator controllers, describing the Cutler-Hammer line of controlling devices designed for use with alternating and direct current motors operating passenger or freight elevators. The booklet illustrates elevator controller apparatus in detail that never before has been shown in a publication. It should be of interest to electricians and others concerned in the problem of elevator design and up-keep.

CHARLES BESLY & CO., 118-124 North Clinton street, Chicago, Ill. Pamphlet on Besly disk grinding practice giving results of comparative circle tests and Helmet spiral circles, practice of machining castings with the Besly disk grinder, showing a large number of manufactured parts that are being machined efficiently and rapidly with the Besly grinder. The pamphlet will be found of general interest by all concerned with the economical finishing of machine parts, apparatus, etc.

WESTERN ELECTRIC COMPANY, 463 West street, New York. Booklet descriptive of the manufacture of lead-covered cable in the Western Electric Company's cable department which is said to be the largest and best equipped cable plant in the world. The booklet illustrates and describes a 600 pair B. & S. gage, paper insulated lead covered cable. It also illustrates the manufacture of telephone cables, and contains a double page illustration on the Hawthorne works, a 143-acre plant.

HILL, CLARKE & CO., Chicago, Ill. Circulars of 3- and 3½-foot Western triple geared radial drills; Chicago duplex bench miller; No. 1 Chicago duplex hand miller with power feed; No. 4 Chicago duplex hand miller, with power feed; No. 3 Chicago duplex hand miller, with power feed; No. 3A Chicago duplex hand miller, with power feed and screw vertical attachment to knee; and circular illustrating feather keyseating as done on the Chicago duplex hand miller, with power feed.

JOHN WILEY & SONS, 43-45 East Nineteenth street, New York. Catalogue of text-books and industrial works for schools, colleges, polytechnic institutes, engineers, architects, chemists, military and naval officers, etc., comprising works on agriculture, architecture, army and navy, assaying, astronomy, chemistry, civil engineering, drawing, electricity and physics, law, mathematics, mechanical engineering, pure and applied mechanics, medicine, metallurgy, mineralogy, mining, sanitary science and miscellaneous.

LODGE & SHIPLEY MACHINE TOOL CO., Cincinnati, Ohio. Folder on the evolution of the Lodge & Shipley "patent head" lathe. A half-tone of the present patent head lathe has superimposed on it three halftone illustrations of the headstock as built in the beginning with the five-step cone with narrow belt, the three-step cone with double back gears, and the all-geared head; the disadvantages of each of these three types are pointed out. The folder will interest those concerned with the development and use of engine lathes.

KOLESCH & COMPANY, 138 Fulton street, New York. Circular of the "Lewis Ideal" tape reel for engineers and surveyors. The diameter of the reel is 5⅛ inches and the weight 10 ounces, the capacity being 125 feet of tape. The frame is made of aluminum alloy and the wearing parts of hardened steel with handle of bronze. It has a high-speed gear which enables the user to wind up 100 feet of tape in about 12 seconds, thus saving much valuable time. The price is $15, with a ¼-inch wide 100-foot steel tape.

MANUFACTURERS' EQUIPMENT & ENGINEERING CO., Boston, Mass. Circular of all-metal sanitary and fireproof equipment for factories, foundries, gymnasiums, public buildings, department stores, offices, hospitals, etc., comprising individual wash bowls in batteries, metal lockers, all steel stools and chairs, steel stools and chairs with inset wood seats, stock and storage racks, metal shelving, metal vault fixtures, improved soda kettles, water heaters and instantaneous mixers, work benches with bench legs, drawing stands, etc.

W. S. ROCKWELL, 50 Church St., New York. Catalogue No. 3 of fuel oil and gas burning appliances comprising Rockwell oil burners, low-pressure oil burners, steam-actuated fuel oil pumping system, belt-driven fuel oil pumping system, positive pressure blowers, steam separators, high-pressure tanks, oil hose, fuel oil storage tanks and useful data and information. The catalogue contains a diagrammatic illustration of a fuel oil furnace installation, showing tank car on switch, storage tank buried in the ground, and pipe connections to oil pump, blower and forge furnace.

ROCKFORD MACHINE TOOL CO., Rockford, Ill. Catalogue of Rockford shapers and planers, comprising 14-inch single gear, 16-inch back-gear, 20-inch back-gear crank shapers, 16-inch Rockford shaper with constant-speed belt drive, 24-inch x 24-inch, 28-inch x 28inch, 32-inch x 32-inch and 36-inch x 36-inch metal planers. The catalogue also illustrates Rockford shapers driven by constant speed and variable speed motors and the Rockford variable speed planer with four cutting speeds and a high-speed constant return. The four-speed gear box is applicable to all sizes of planers built by the company.

J. T. SLOCOMB COMPANY, Providence, R. I. Pamphlet on measurement, containing suggestions in regard to accurate and economical measuring in machine construction. The pamphlet refers to the measurement with the common rule, with inside and outside calipers of the old type and external and internal micrometer calipers of the type made by the company. The construction of the Slocomb micrometer heads is shown and the various styles for shop equipment, also measuring machines, gages, etc., that are employed in the manufacture of Slocomb micrometers to secure a high degree of accuracy.

H. W. JOHNS-MANVILLE CO., 100 William St., New York. Bulletin No. 2, illustrating and describing the "Linolite" system of electric illumination, including a new line of desk lamps recently placed on the market. Proper illumination of desks is a difficult problem to solve. Most of the lamps used for the purpose to-day are the ordinary incandescent bulb lamps placed in a small reflector which throws the light all on one section of the desk, leaving the balance insufficiently lighted. The tubular "Linolite" lamps are 12 inches long between centers and distribute light more evenly and over a larger section of the desk than bulb lamps.

GEORGE H. GIBSON COMPANY, Tribune Building, New York. Pamphlet entitled, "Advertising and Its Service," being a reprint from the New York *Evening Post*, describing the economics of advertising, especially as regards the engineering and mechanical industries. It shows that contrary to academic opinions, properly directed advertising reduces the cost of distribution of goods. It provides the salesmen with a great number of selling opportunities in a given territory and in a given time. It performs a preliminary, but necessary work of informing and educating the prospective user as to the nature, possibilities and profitableness of improved machinery.

NATIONAL BRAKE & ELECTRIC CO., Milwaukee, Wis. Catalogue of National motor-driven air compressors, type "3VS." This type has three vertical cylinders with pistons driven by a three-throw crankshaft, direct-connected to an electric motor. The construction of a compressor is shown in detail by illustrations of the upper and lower half of the frame with crankshaft in place, herringbone gear and pinion, piston connecting-rods and cylinders mounted and disassembled, suction and discharge valves, etc. The catalogue also illustrates direct and alternating current motors, combined automatic controlling devices, air pump governor, air compressor equipment mounted on wheels for railroad service operating rock drills, pneumatic drills, etc., and the air lift well system of pumping water from wells by compressed air. It concludes with tables of dimensions, capacities of cylinders and air receivers.

TRADE NOTES

ROCKFORD LATHE AND DRILL COMPANY, Rockford, Ill., has increased its capital stock from $20,000 to $50,000.

HAMPDEN BROTHERS COMPANY, Springfield, Mass., maker of brass, composition and aluminum castings and specialties in these metals is building an addition to its foundry, 36 by 132 feet.

DUCKWORTH CHAIN AND MANUFACTURING COMPANY, Springfield, Mass., maker of chains for bicycles, automobiles, etc., and specialties, has built an addition that will increase its capacity about 75 per cent.

CARPENTER STEEL COMPANY, Reading, Pa., announces the appointment of Mr. Fred. A. Bigelow, formerly its representative in New England, as manager of its Cleveland branch, with office and warehouse at 1304 West Sixth street, Cleveland, Ohio.

COLUMBUS PNEUMATIC TOOL COMPANY, 1432 Parsons avenue, Columbus, Ohio, has changed its name to the Dunlap Engineering Company, with T. C. Dunlap president and treasurer, W. J. Dolan, sales manager, and J. H. White, superintendent, as heretofore.

J. A. FAY & EGAN CO., Cincinnati, Ohio, has sold to the Wright Bros., Dayton, Ohio, for use in their aeroplane factory, ten woodworking machines. Among these are a high-duty planer that will cut wood so thin that it is transparent, a special shaper, cut-off saw, mortiser and tenoner.

M. L. ANDREW & CO., Cincinnati, Ohio, are erecting a two-story brick and stone building at the corner of Colerain avenue and Alabama street, which will be ready for occupancy about the middle of May. The company is in the market for a grinder, gear-cutter, planer, radial drill, automatic screw machine and engine lathes.

EDGEMONT MACHINE COMPANY, Dayton, Ohio, manufacturer of friction clutch pulleys for countershafts and extended sleeve clutches for line-shaft duty, has recently added a number of new and specially designed machines to its already fine equipment, and is now in position to take care of its rapidly increasing clutch business.

H. W. JOHNS-MANVILLE CO., 100 William St., New York, because of rapidly increasing business, has moved its Chicago branch now at Randolph St. to the four-story and basement building at Nos. 27-29 Michigan Ave., with 32,500 square feet of floor space. Office, store and warehouse are all under one roof. Its Baltimore, Md., office, store and warehouse has been located at 30 Light St.

CHARLES T. MAIN, formerly 201 Devonshire street, Boston, Mass., has moved into more commodious offices in 817-833 of the new Boston Safe Deposit and Trust Company building. He will be better prepared than ever to conduct the work in engineering of textile mills and other industrial plants, water power and steam power development, examination and reports on plants with reference to their value, reorganization and development.

LODGE & SHIPLEY MACHINE TOOL COMPANY, Cincinnati, Ohio, has recently added an excellent dining hall to its factory. The dining hall building was formerly a large residence, which has been handsomely and tastefully decorated, and furnished appropriately for the purpose. Many beautiful pictures hang on its walls, which Mr. Shipley imported from Germany. The entire executive and selling force and heads of various operating departments take their meals here with all the conveniences of a first-class café.

TERMINAL ENGINEERING COMPANY, 30 Church street, New York, is the American office, in charge of Mr. E. C. Johnstone, agent for the James Hendry laminated leather products manufactured in Bridgeton, Glasgow, and Birmingham, Great Britain. An American factory has been completed near Newark, N. J., for the manufacture of these products, which comprise Hendry's laminated leather belting for dynamos, motors, and all classes of main drive also Hendry's helically laminated round leather belting to displace rope in rope drives.

JOHN B. MORRIS MACHINE TOOL COMPANY, Court, Harriet and Vogt streets, Cincinnati, Ohio, has been incorporated under the laws of Ohio with a capital stock of $125,000, and has purchased the machine tool trade formerly conducted by the J. B. Morris Foundry Company. Plans are being completed for a new factory building with a floor space of over 30,000 square feet, to be used in the manufacture of machine tools formerly built by the J. B. Morris Foundry Company. Additional machine equipment will be installed and the new company expects to increase its line of machine tools.

GREEN FUEL ECONOMIZER CO., Mattewan, N. J., in connection with the Rhode Island Construction Engineering Co., worked out a heating system for the Waterbury Castings Co., Waterbury, Conn., which is giving satisfactory results. The new foundry of the Waterbury Casting Co. has a capacity of 515,000 cubic feet. The walls are nearly all glass and the problem was difficult to handle, but by the arrangement of heater mains and discharge pipes, the heated air is discharged, in such a manner as to make working conditions uniformly comfortable and to displace the smoke, causing it to rise to the roof.

INTER-OCEAN STEEL COMPANY, 217 Railway Exchange, Chicago, Ill., expects to have its new plant at Chicago Heights ready to produce locomotive and car wheel tires, tire rings and ore crushing machinery, forged and rolled weldless steel flanges for use on high pressure steam and water pipe boilers, and other rolled rings, about April 1. The machinery was designed by Mr. Julian Kennedy, who enjoys a world-wide reputation as a designer, and tire mill expert. The mills have an unusual capacity; they will roll tires of considerably larger diameter and of greater width and section than any other in existence.

GOLDSCHMIDT-THERMIT CO., 90 West St., New York, publishes a quarterly periodical called *Reactions*, devoted to the science of aluminothermics. The fourth quarterly issue for 1909 contains an interesting description of the repair of a 48-ton pulley in the wilds of North Carolina for the Consolidated Nickel Co., under conditions of great difficulty. The repair was successfully made with thermit, and the pulley is shown before and after the repair was made. Views of Sylva and its inhabitants give the reader a good idea of the limited resources of the region for making the heavy repairs that were very simply performed with thermit.

INGERSOLL-RAND COMPANY, 11 Broadway, New York, held its annual convention of managers and agents in New York, February 1 to 5. Mr. W. L. Saunders, president, presided at the meetings. The party left New York by private car February 1 for Easton, Pa., and passed en route through the Musconetcong Tunnel, the first railway tunnel in America driven entirely by machine drills. The rock drills used in this work were built by one of the pioneer companies now comprising the Ingersoll-Rand Company. The first day was spent at the Easton, Pa., plant examining the line of compressors, stone channelers, hammer drills, core drills, and pneumatic tools built in these shops. The second day was devoted to the Phillipsburg, N. J., works, inspecting the rock drills, electric-air drills, coal cutters and large compressors, which are the products of this plant. The party then went to the Painted Post, N. Y., shops by special train, where, on February 3, the compressors, rock drills, hammer drills, pneumatic tools and pneumatic hoists produced at this plant and at the Athens, Pa., shops were examined. The party returned to New York by special train and devoted February 4 and 5 to business meetings at the Hotel Astor. A social feature of the convention was a banquet and theatre party on Friday evening, February 4. Forty-two representatives of the company were in attendance.